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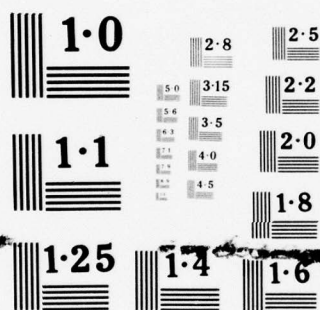
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# NAVAL POSTGRADUATE SCHOOL

Monterey, California



## THESIS

HIGH FREQUENCY IONOSPHERIC  
PROPAGATION PHENOMENA

by

Richard Robert Rowe

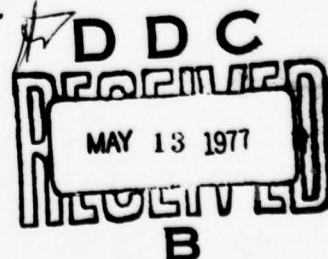
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→ minutes. The main thrust of this paper has been the visual examination of the data on a graphics display with the idea of identifying drastic and unexpected changes in either individual signals or the entire wavefront; those changes being due, at least in part, to signal transformation resulting from various ionospheric phenomena. In addition, an in-depth statistical study was conducted on several of the specific signals with the hope of aiding in the formulation of an algorithm to efficiently automate the receiving system's sensitivity settings.

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HIGH FREQUENCY IONOSPHERIC PROPAGATION PHENOMENA

by

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Lieutenant, United States Navy  
B.S. Ed., Eastern Montana College, 1968

Submitted in partial fulfillment of the  
requirements for the degree of

MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

from the  
NAVAL POSTGRADUATE SCHOOL  
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## ABSTRACT

PROJECT BRIGHAM was a Department of Defense data collection effort wherein 890 kHz wide samples of the HF spectrum were acquired using a 25 Hz sampling rate with 2.8 kHz resolution for a period of up to 2.4 minutes. The main thrust of this paper has been the visual examination of the data on a graphics display with the idea of identifying drastic and unexpected changes in either individual signals or the entire wavefront; those changes being due, at least in part, to signal transformation resulting from various ionospheric phenomena. In addition, an in-depth statistical study was conducted on several of the specific signals with the hope of aiding in the formulation of an algorithm to efficiently automate the receiving system's sensitivity settings.

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## I. OBJECTIVES

The objectives of the project were: (1) to continue the visual, or graphical, analysis of the BRIGHAM data (the initial effort of which was reported in Ref. 1) in an attempt to verify anomalous signal behavior already documented and to discover any new anomalies which might be present; (2) toward that end, to make whatever changes were necessary in both the programs and data handling procedures to meet either new system constraints or to enhance over-all project efficiency; and (3) to analyze the data from a statistical standpoint (via two entirely new computer programs) in an effort to determine how often and by what amount (in decibels) several different classes of signals change.

The format of the data, particularly that of the 2.4 minute time duration limitation (although there were several time-wise contiguous data sets), made long term analysis, both visual and statistical, impossible. In addition, the daily intercept times for the data sets precluded any significant effort being made to correlate signal characteristics from even approximately the same time of the day.

## II. INTRODUCTION

It is well documented that as radio signals traverse the ionosphere (including signals bounced off of one of its layers) they are often changed in a manner that goes beyond simple attenuation due to the distance travelled. Both the make-up of the ionosphere itself (how many ions are present at any one time, the elusive Sporadic-E phenomenon, night-day asymmetry and the geomagnetic non-reciprocity to name but a few) and the more dramatic disruptions of ionospheric behavior (solar flare caused magnetic storm activity, polar cap absorption and the auroral displays are three) team with the more common, every day phenomena of "Faraday Rotation" and noise-producing lightning storms to alter any signal with which any or all of them come in contact. The results can be severe attenuation, pronounced amplification, "ducting", "whistlers", and fading (sometimes called the Dellinger Effect). References 2 - 6 were excellent sources for ionospheric phenomena information.

It was felt that the application of graphical techniques to signals which had traversed the ionosphere might add some insight into the problem of exactly what happens to these signals.

For the most part, the visual presentation techniques, shown in various stages in Fig. 1, used in this study were the same as those presented in Ref. 1. However, some changes have been made and will be discussed in detail in the appropriate section. As in Ref. 1, interesting sets of scans have been reproduced as graph plots (using the VERSATEC plotter) for further analysis and presentation in

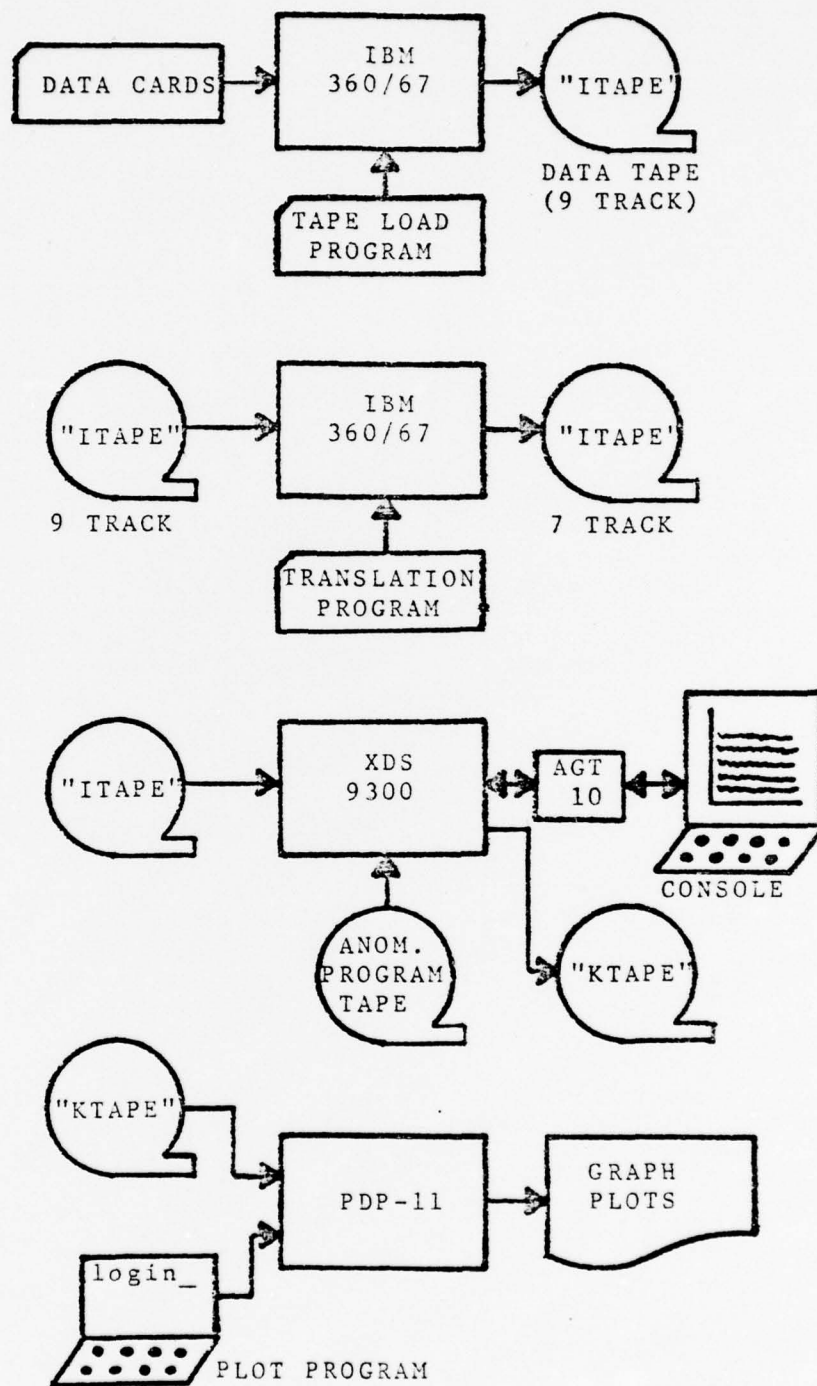


Figure 1 - ANOMALY DATA PROCESSING STAGES

this paper. All thirty-four of the previously unanalyzed complete data sets were studied with varying degrees of success concerning anomalies (or, least, perceived to be so) found therein.

The swept-tuned receiver and associated equipment used to acquire and record the data sets is an operational receiver equipment used for other than experimental data gathering. Its proper operation requires frequent tuning of numerous sensitivity adjustments. How often and by what amount these attenuators and thresholds are changed have a profound effect on the performance of the equipment. Therefore, programs MIN/MAX 1 and MIN/MAX 2 were written in an effort to accumulate enough statistical data from the sets to warrant the recommendation of some appropriate algorithm for controlling the attenuator adjustments. Section IV of this paper will address itself to that topic.

#### A. NATURE OF THE DATA

The data was gathered using a swept-tuned receiver with either an omnidirectional or 12 degree beam antenna. The data sets were produced by sampling the receiver output at a 25 Hz sampling rate as it scanned downward through an 890 kHz band. Each data set consists of, at most, 3597 scans (each scan being composed of 318 contiguous 2.8 kHz wide bins moving down in frequency as the bin number increases) placed on 7194 cards. Card one gives amplitude information, in 2 dB high quantization levels, for bins 1 through 160 while information on bins 161 through 318 is found on card two. The quantization levels are given in 5-bit binary words with even numbered bin information found in rows 11 through 3 while odd numbered bin information is in rows 5 through 9. In addition, each card has the card number and



set number punched in row 12 for accounting purposes. With each set there is a parameter card which delineates the date and time of signal acquisition, base frequency, antenna configuration and attenuation applied.

Of approximately 150 data sets recorded, forty-four were made available for this study. Figure 2 is a table of pertinent information concerning the forty-two complete sets analyzed in Ref. 1 and this paper.

#### B. CHANGES IN THE GRAPHICAL ANALYSIS PROCEDURE

Equipment reconfigurations since the graphical analysis procedure was formulated and reported in Ref. 1 and efforts to make the data handling more efficient demanded several changes both in procedure and in the two main analysis programs, Anomaly A and Anomaly B. Specific information concerning the workings of the two programs may be found in Ref. 1, particularly in section II B.

First of all, the sheer number of binary cards to be transcribed onto magnetic tape (nearly a quarter of a million) obviated the card-to-tape technique used previously. A much faster and far more reliable procedure was initiated wherein the IBM 360/67 system, belonging to the W. R. Church Computer Center, was used after normal working hours. The cards were first read onto 9-track tapes (800 BPI, even parity) and then transcribed to the 7-track tapes (556 BPI, odd parity) required for the XDS-9300 computer. Partial dumps were made of all sets from both the 9- and 7-track tapes to ensure that the cards read onto the tapes properly and that the tape-to-tape translation was successful. The programs used to read the cards onto tapes, translate the 9- to 7-track and dump the tapes for

| SET | DATE/TIME      | FREQUENCY              | ANTENNA | ATTENUATION |
|-----|----------------|------------------------|---------|-------------|
| 3   | 100522Z MAR 70 | 03501                  | OMNI    | 8 DB        |
| 4   | 101030Z MAR 70 | 18000                  | OMNI    | 0 DB        |
| 5   | 120555Z MAR 70 | 06000                  | OMNI    | 10 DB       |
| 7   | 121205Z MAR 70 | 11000                  | OMNI    | 8 DB        |
| 8   | 130505Z MAR 70 | 05000                  | OMNI    | 18 DB       |
| 9   | 131018Z MAR 70 | 13000                  | OMNI    | 10 DB       |
| 15  | 181036Z MAR 70 | 12000                  | OMNI    | 10 DB       |
| 16  | 181705Z MAR 70 | 10000                  | OMNI    | 10 DB       |
| 18  | 191105Z MAR 70 | 14000                  | OMNI    | 10 DB       |
| 20  | 191715Z MAR 70 | 04000                  | OMNI    | 4 DB        |
| 21  | 020400Z APR 70 | 05000                  | OMNI    | 20 DB       |
| 22  | 020400Z APR 70 | 05000                  | BEAM    | 20 DB       |
| 24  | 031400Z APR 70 | 11000                  | OMNI    | 10 DB       |
| 25  | 031400Z APR 70 | 11000                  | BEAM    | 10 DB       |
| 31  | 051400Z APR 70 | 11000                  | OMNI    | 0 DB        |
| 32  | 051407Z APR 70 | 11000                  | BEAM    | 4 DB        |
| 33  | 060400Z APR 70 | 05000                  | OMNI    | 24 DB       |
| 34  | 060400Z APR 70 | 05000                  | BEAM    | 24 DB       |
| 35  | 061400Z APR 70 | 11000                  | OMNI    | 0 DB        |
| 36  | 061406Z APR 70 | 11000                  | BEAM    | 4 DB        |
| 37  | 070400Z APR 70 | 05000                  | BEAM    | 10 DB       |
| 38  | 070400Z APR 70 | 05000                  | OMNI    | 10 DB       |
| 39  | 071409Z APR 70 | 11000                  | BEAM    | 4 DB        |
| 40  | 071400Z APR 70 | 11000                  | OMNI    | 0 DB        |
| 41  | 080412Z APR 70 | 05000                  | BEAM    | 14 DB       |
| 51  | 132113Z APR 70 | 07000                  | OMNI    | 14 DB       |
| 52  | 142100Z APR 70 | 07000                  | OMNI    | 14 DB       |
| 53  | 142109Z APR 70 | 07000                  | BEAM    | 14 DB       |
| 54  | 161030Z APR 70 | 13650                  | OMNI    | 2 DB        |
| 61  | 291005Z APR 70 | 15000                  | OMNI    | 0 DB        |
| 63  | 050830Z MAY 70 | 14600                  | OMNI    | 0 DB        |
| 67  | 060955Z MAY 70 | 14000                  | OMNI    | 4 DB        |
| 72  | MORSE TEST -   | PARAMETERS UNAVAILABLE |         |             |
| 73  | MORSE TEST -   | PARAMETERS UNAVAILABLE |         |             |
| 80  | 100000Z MAY 70 | 10000                  | OMNI    | 10 DB       |
| 81  | 100005Z MAY 70 | 04000                  | OMNI    | 10 DB       |
| 91  | 121100Z MAY 70 | 13616                  | BEAM    | 4 DB        |
| 126 | 221230Z MAY 70 | 08200                  | OMNI    | 0 DB        |
| 138 | 261210Z MAY 70 | 22000                  | OMNI    | 4 DB        |
| 139 | 261215Z MAY 70 | 18000                  | OMNI    | 4 DB        |
| 147 | 272045Z MAY 70 | 16000                  | OMNI    | 13 DB       |
| 148 | 272100Z MAY 70 | 10000                  | OMNI    | 18 DB       |

Figure 2 - DATA SET INFORMATION

quality control can be found at the end of this paper.

This new system of data loading resulting in the requirement to change the sections of the Anomaly A and Anomaly B programs referring to data read-in. This was accomplished with little difficulty.

Next, a metasympol subprogram was added to each of the analysis programs to enable entire files (data sets) to be skipped when a specific file required was located other than first on a tape. By calling the routine "FORSCN" a keyboard-entered number of files (NFILE = ) would be passed over. This proved to be extremely valuable as a time and labor saving device. The routine "BAKSCN" was also available for backing over entire files but chronic tape drive malfunctions negated the use of this even more valuable tool.

One final major program change was dictated by a computer center equipment reconfiguration wherein the CALCOMP 563 plotter was no longer available. The new system to be used was the PDP-11 computer in conjunction with a VERSATEC plotter. This change required modifications of the analysis program sections dealing with the processing of the output data (desired plots from the AGF-10 screen), found at the very end of the main program, and the generation of a new subroutine, called the Header Subroutine, which packs the header data into the proper format for the plotting unit. In addition, a PDP-11 plot package (used to interface the data tape with the plotter) had to be extensively modified to meet the demands of this anomaly data. Listings of the revised Anomaly A and B programs, the metasympol program for calling "FORSCN" and "BAKSCN" and the PDP-11 plot routine (called "aa.c" for Anomaly A plots - this routine alone is listed since the one utilized for the Anomaly B graph plots differs only in a few of the

approximately 400 lines comprising "aa.c") can be found at the back of this paper. Subroutines GINP, GINPUT, FNS and VCD were not changed and, hence, are not listed in this paper but may be found in Ref. 1.

### C. ANOMALY A AND B PLOTS

The plots which have resulted from the graphical analysis portion of this study require some prior explanation. Due to the data handling restrictions imposed by the XDS-9300 computer, only a small portion of the data in each set could be viewed at any one time. This resulted in some difficulty in visualizing what could be long-term (time wise) or wide (frequency wise) phenomena and demanded that each set be analyzed several times before the entire set had been viewed.

The Anomaly A plots consist of twenty scans (signal wavefronts sampled 0.04 seconds apart - or further if scans were deliberately skipped to view long-term effects) with the most recent scan in time falling at the bottom of the picture. The scans could be brought onto the screen in any number up to, and including, twenty at a time. As shown in Fig. 3, the vertical axis is marked off in 5 dB increments which apply only to the bottom scan (called "base scan"). The horizontal axis is divided into ten 28 kHz wide sections each composed of ten frequency bins 2.8 kHz wide for a total of 100 frequency bins and 280 kHz. This width can be varied to other than 100 bins if desired. The leftmost bin (termed the "base bin") is selected by keyboard input, thus allowing the analyst to slide up and down the data set (frequency-wise) at will. The scale along the horizontal axis, then, consists of increments of ten bins starting with the "base bin" number at the origin. The term "base freq"



refers to the base frequency of the data set and decreases in 2.8 kHz increments as the bin number increases. Shading has been provided on some of the plots to highlight the suggested anomaly.

The Anomaly B plots are a combination of the Anomaly A plot technique and a modification which enables the analyst to view selected bins (signals) in the time vs. amplitude domain. At the bottom of each plot are five scans (Anomaly A style) used to aid in the selection of the bins to be plotted in the upper traces (see Fig. 4). In addition to the restricted number of scans to be seen at one time (only 5), computer limitations required that the number of frequency bins presented be reduced to eighty. Other than those changes, discussion of the Anomaly A plots is also valid for the lower set of Anomaly B plots. The upper set of Anomaly B plots is a collection of five keyboard-selected signals chosen from among the scans below. The traces are numbered one to five, from top to bottom respectively. The horizontal axis is a time line composed of eighty data points at least 0.04 seconds apart (depending upon the number of scans skipped, if any) with the oldest point at the extreme right side of the trace) with the hash marks on the vertical axis referring to 10 dB amplitude levels.

As seen to some extent in the Anomaly A plots and, more markedly, in the Anomaly B plots, the scans look fractured in appearance. This was not the result of intentional programming, rather it was the product of the new PDP-11/VERSATEC plot routine combination.

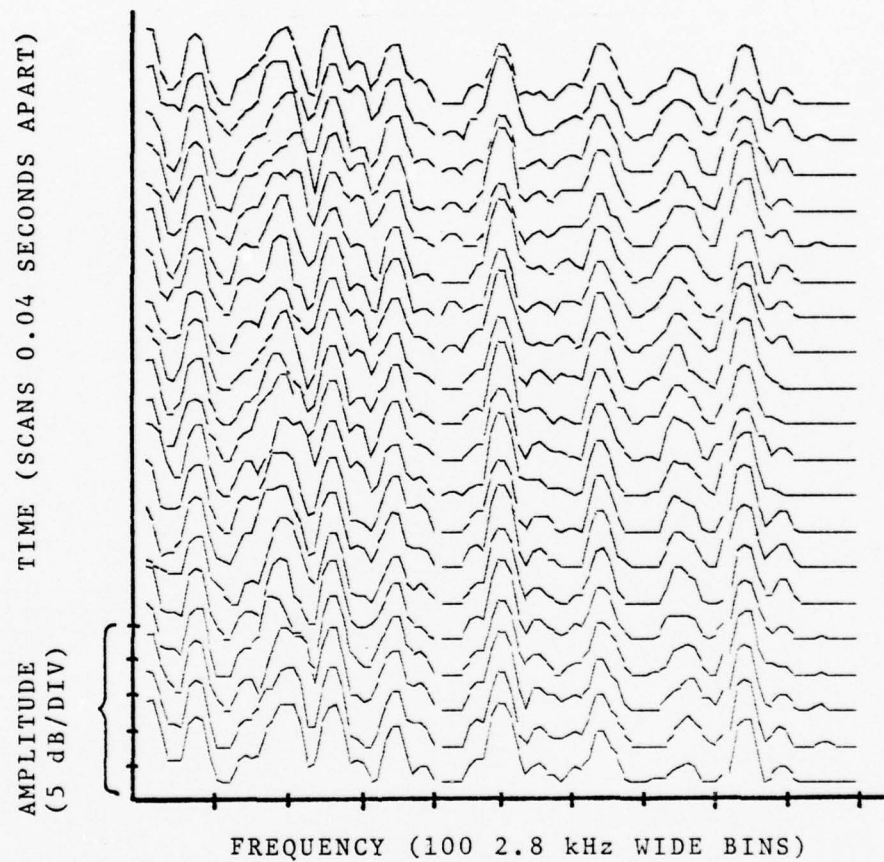


Figure 3 - SAMPLE ANOMALY A PLOT

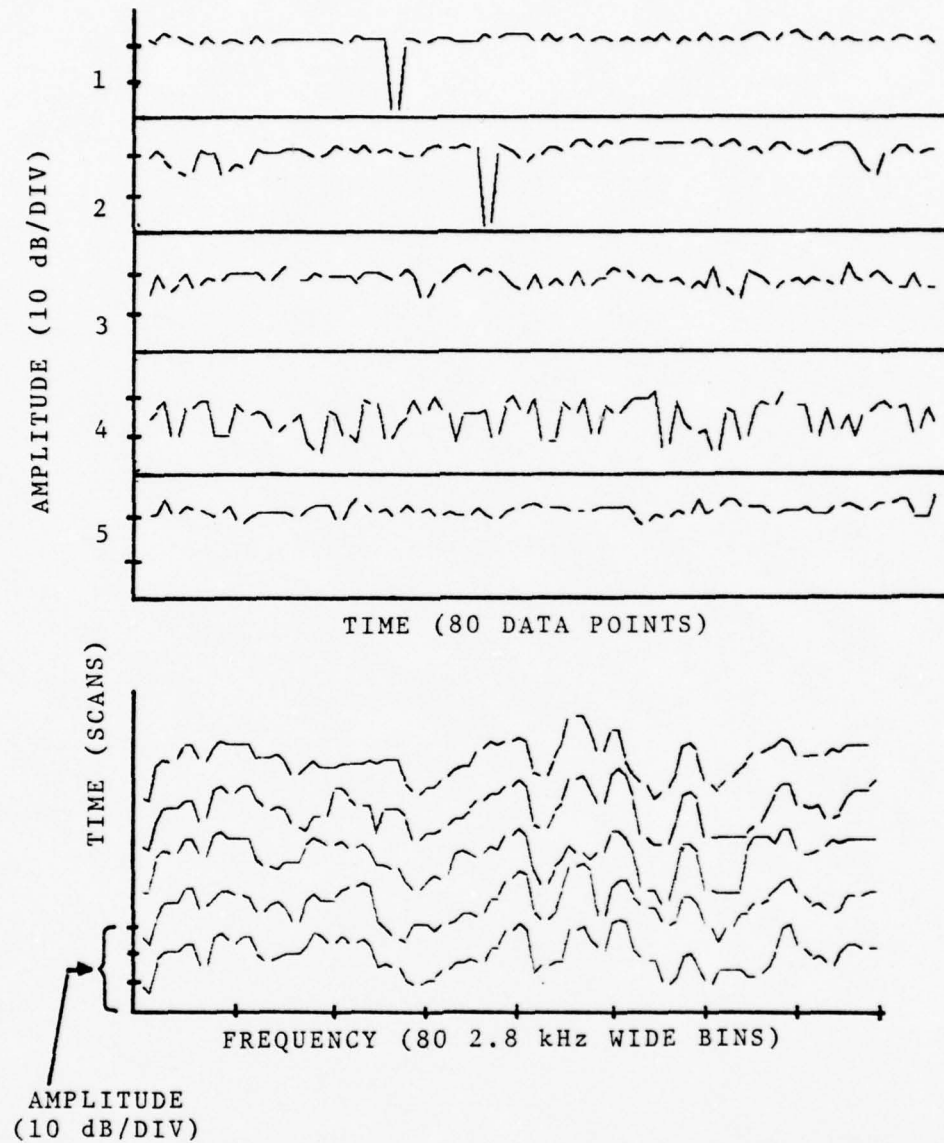


Figure 4 - SAMPLE ANOMALY B PLOT

### III. GRAPHICAL ANALYSIS

#### A. DISCUSSION

Prior to initiation of the graphical analysis process via programs Anomaly A and B, an enumeration of many of the possible "anomalies" expected was made. This was not to imply either that signals which had been markedly affected by the ionosphere would only exhibit these graphical manifestations of anomalous performance or that all forms of signal anomalies would be seen by the analyst. This enumeration procedure was merely an attempt to "visualize" what effects those signal-changing ionospheric phenomena discussed in the introduction might have on the data sets yet to be analyzed. Although no attempt was made to make this study's "anomalies" conform with those identified in Ref. 1, there has been an attempt to verify any previously seen.

The graphical effects on the signal waveforms expected were:

1. a sudden enhancement/depression of one or more signals (long or short term);
2. an abrupt discontinuity across an entire wavefront or portion thereof;
3. a signal "bump" or "valley" moving either up or down in frequency as the wavefront

progresses (Fig. 4, Ref. 1 refers);

4. a shift in frequency of one or more signals (either short term, long term or aperiodic in nature);
5. an unexplainable enhancement of one or more signals with a concomitant depression of one or more signals at the same time in the same data set;
6. a complete loss of continuity of the signal wavefront for variable periods of time;
7. unexpected variations in one or more signal contours as the wavefront progresses;
8. any out-of-the-ordinary graphical implication of anomalous performance.

Effects 1, 2, 4, 6, and 8 were discerned in the present study while several of these, plus effects 3, 5, and 7, were reported in Ref. 1.

#### B. ANOMALY & ANOMALIES

As shown in Ref. 1 and verified in this paper, most of the data sets (when viewed on the graphics terminal) exhibited a great measure of uniformity in signal makeup in the time domain and did not yield any obvious graphical anomalies. In fact, fully fifty per cent of the BRIGHAM data sets failed to provide any reportable irregularities in signal pattern with the other fifty per cent giving fairly uniform signal wavefronts for most of the time recorded.

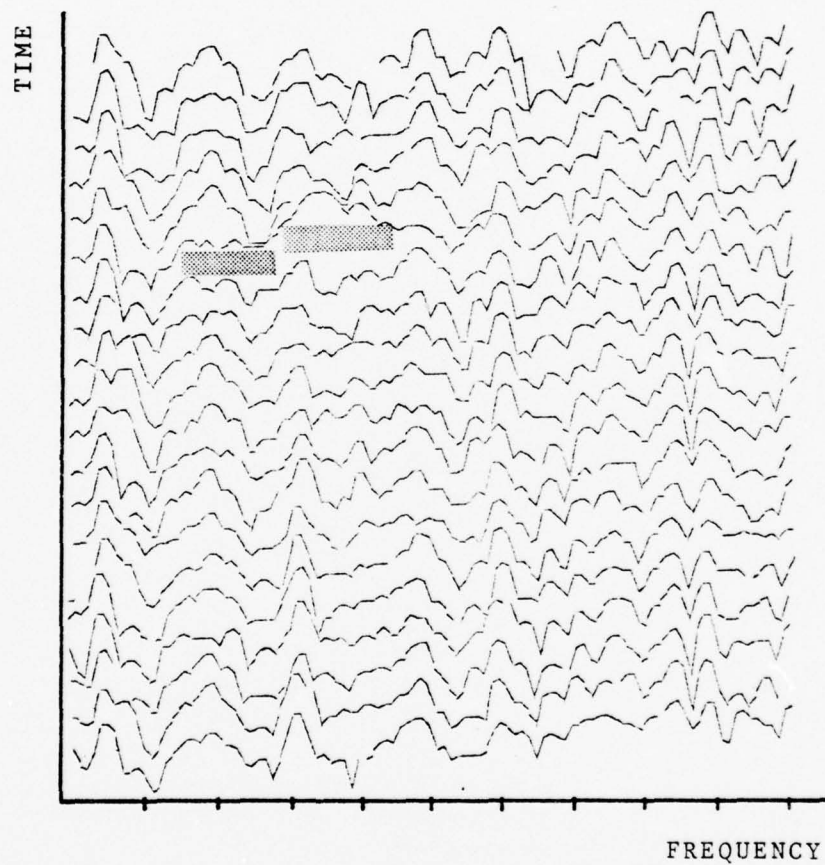


The latter group did, however, exhibit anomalous (or, at least, assumed to be so) characteristics which were verifications of performance reported in Ref. 1 or were newly discovered. The uniformity mentioned above aided immeasurably in the detection of anomalies since even a slight wavefront variation could be discerned in the midst of otherwise uniform signal progression.

Figures 5 and 6 are two examples of minor discontinuities (affecting 30 to 40 bins - approximately 100 kHz) which appear to be the result of a multi-signal amplitude enhancement for a very short period of time. This effect was found scattered through almost half of the thirty-four data sets viewed via Anomaly A. Figure 7 is an example of aperiodic discontinuities which ran across almost all of the entire data set bandwidth. This change did not occur over the entire time duration of the set and, as mentioned above, could not be traced over its entire frequency spectrum. This type of discontinuity was also found in data sets 33 and 80. Both of the discontinuity examples were anticipated although the latter form holds the most promise, anomaly-wise.

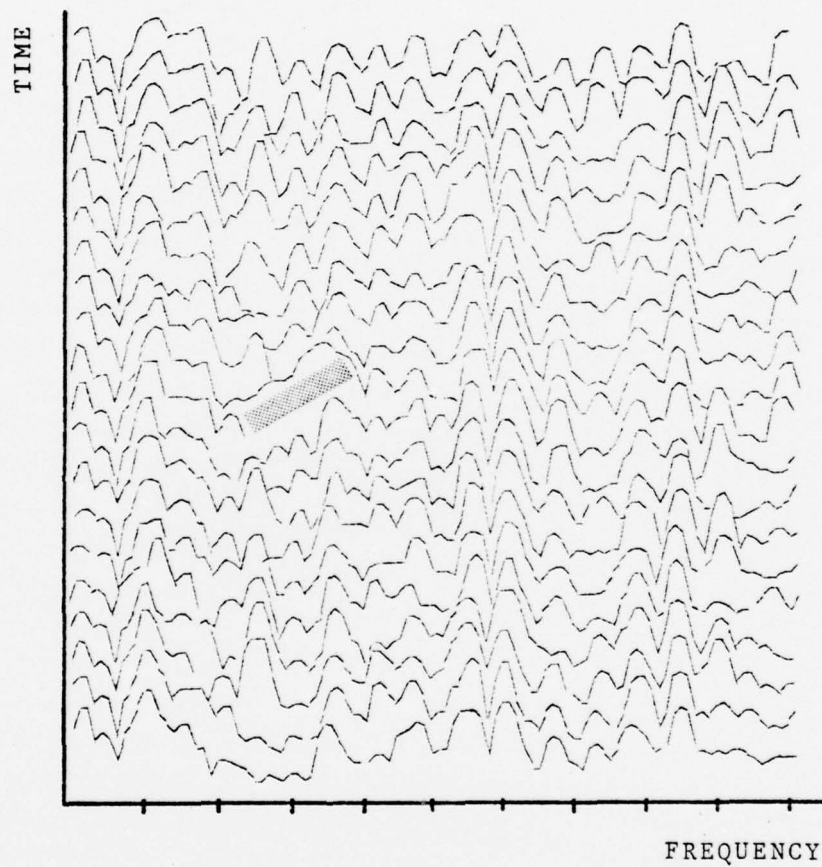
Fading was another effect expected but the examples found were somewhat surprising in that it was anticipated that the entire frequency bandwidth of a signal wavefront (890 kHz) would be affected. This proved not to be the case, with all of the examples of fading implicating at most 20 frequency bins at a time. Figure 8 shows the signal centered on bin 148 fading in and out, a process which lasted several seconds. Figure 9 shows a much smaller time-duration fading centered on bin 24.

A third type of possible anomalous activity is that of the shifting, up or down in frequency, of either a single signal or entire 390 kHz wide signal scans. The precise



Set 3, Base Scan 141, Base Freq 3.5 MHz, Base Bin 1

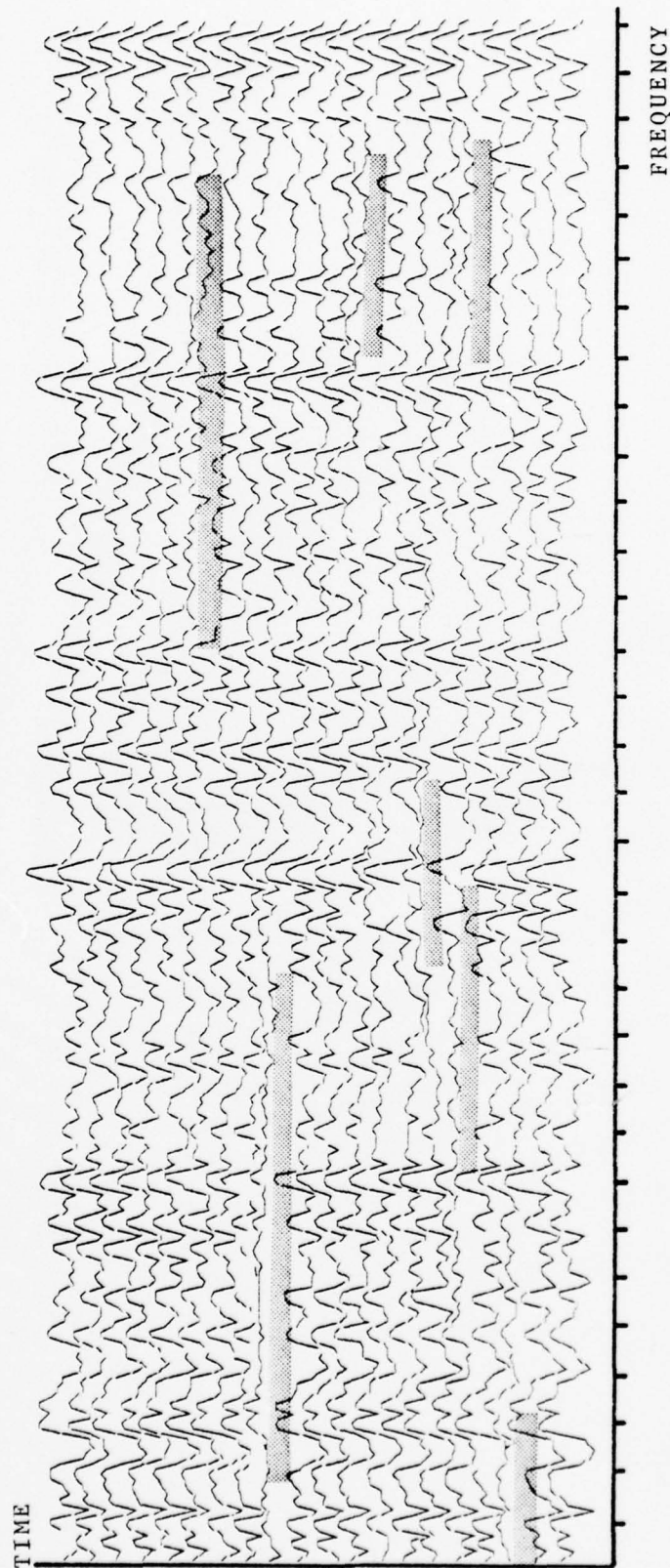
Figure 5 - NARROW DISCONTINUITY EXAMPLE #1



Set 3, Base Scan 1023, Base Freq 3.2 MHz, Base Bin 100

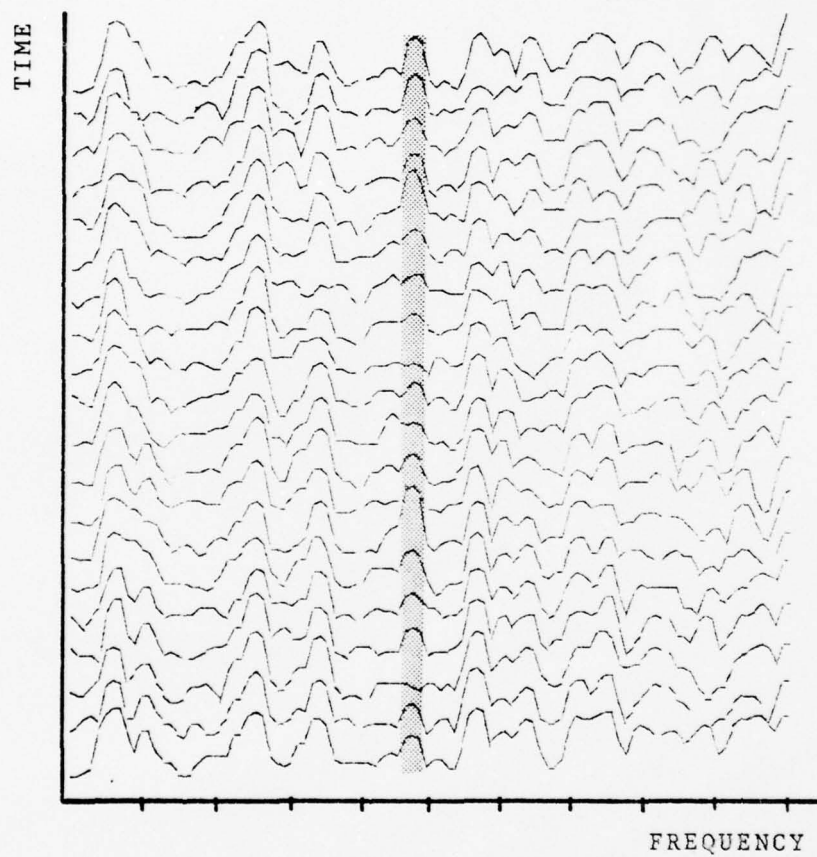
Figure 6 - NARROW DISCONTINUITY EXAMPLE #2





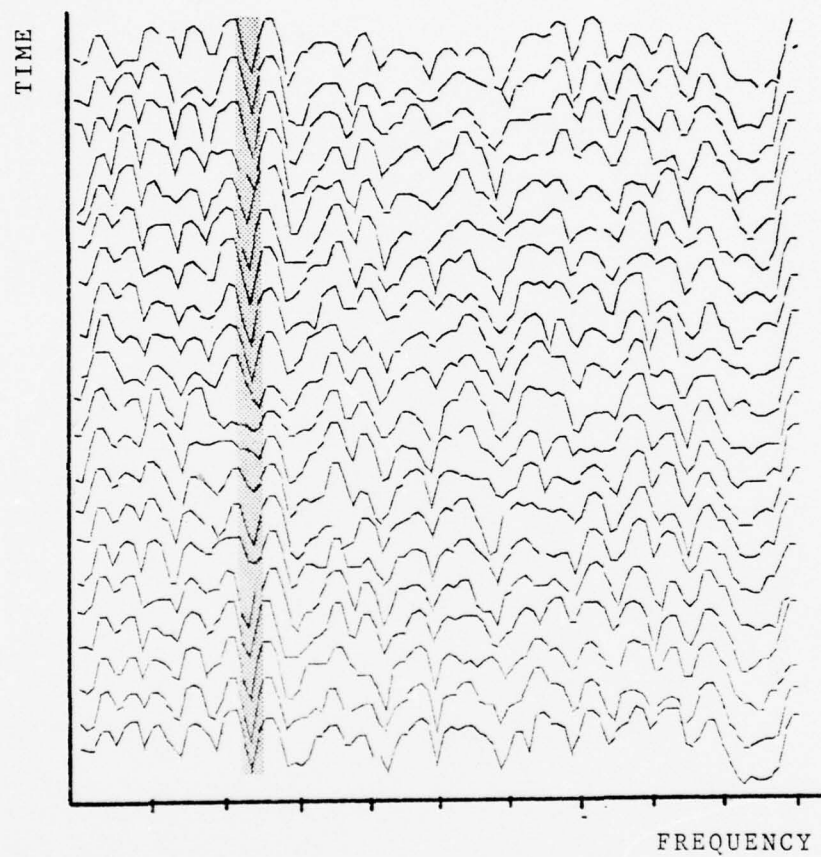
Set 67, Base Scan 690, Base Freq 14 MHz, Base Bin 1

Figure 7 - WIDE DISCONTINUITY EXAMPLE



Set 53, Base Scan 544, Base Freq 6.7 MHz, Base Bin 100

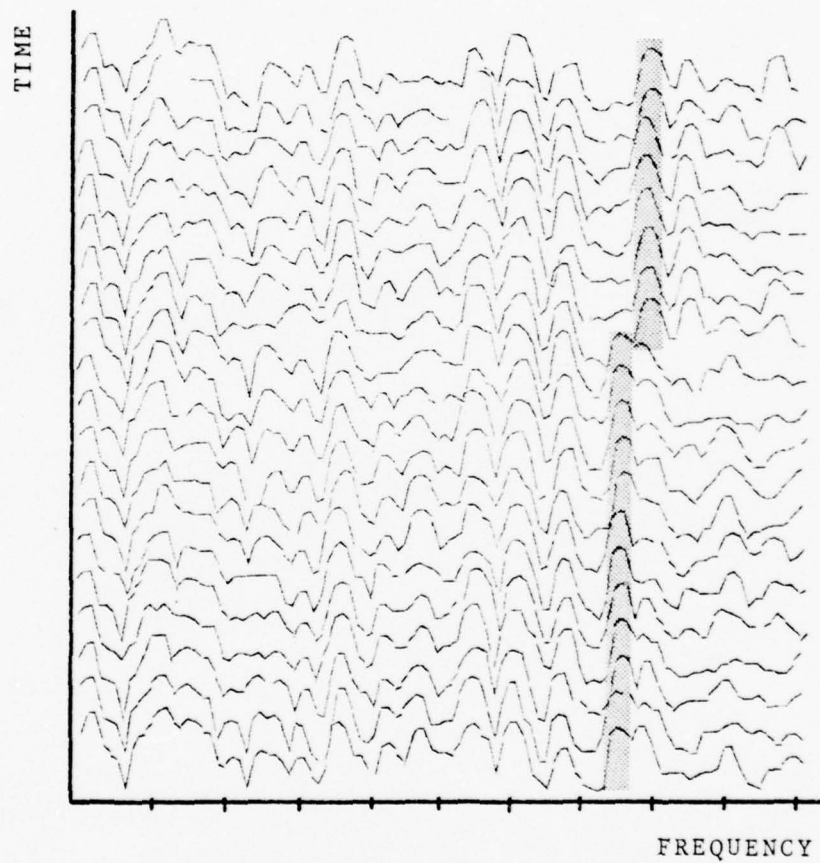
Figure 8 - FADING EXAMPLE #1



Set 33, Base Scan 270, Base Freq 5 MHz, Base Bin 1

Figure 9 - FADING EXAMPLE #2

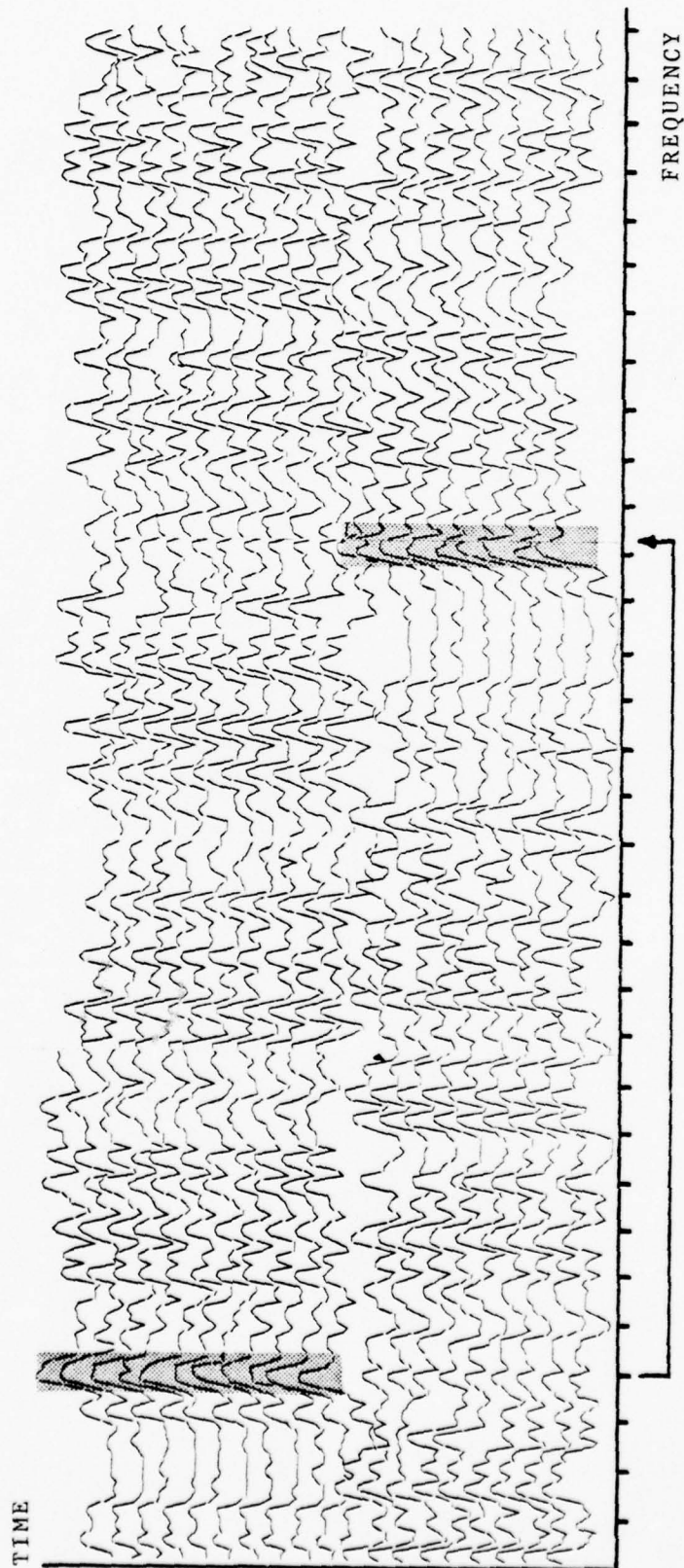
explanation of this phenomenon is not available but it must be kept in mind that malfunctions in the receiver system itself could be the cause rather than some ionosphere-related activity. Figure 10 shows a possible left shift (approximately 3 bins) and distortion of two side-by-side signals. Figures 11 and 12 are examples of apparent frequency shifts of 160 bins both of which turned out to be data set problems. Since each scan is composed of two data cards of binary coded amplitudes (bins 1 - 160 on card one and bins 161 - 318 on card two), the order in which the two cards appear and, as importantly, the existence of both cards for each scan are absolutely vital to the correct representation of the signal wavefront. For example, if card one of a scan is missing, then card one of the next scan is taken as card two of the former. This has a domino effect which will graphically manifest itself as an apparent shift of 160 bins in all subsequent scans. Figure 11 illustrates precisely this effect. A manual search of the missing from the set. Figure 12 is an interesting twist on this problem in that the signal apparently shifted 160 bins to the right (or, down in frequency) and then, three scans later, shifted right back again. Another search of the cards showed that, as expected, two cards were missing, one to cause the initial 160 bin right shift and a second to return the data cards to their correct sequence three scans later. One last example of signal shifting is by far the most interesting of the lot. As illustrated by Fig. 13, there is a shift down in frequency of approximately 12 bins (34 kHz) affecting the entire 318 bins (890 kHz bandwidth) of aperiodically spaced scans. This phenomenon was seen over the entire length of the data set at apparently random intervals. Data sets 138 and 143 also exhibited this aperiodic frequency shifting, although the number of bins by which the scans were shifted varied slightly over the three sets.



Set 3, Base Scan 336, Base Freq 3.2 MHz, Base Bin 100

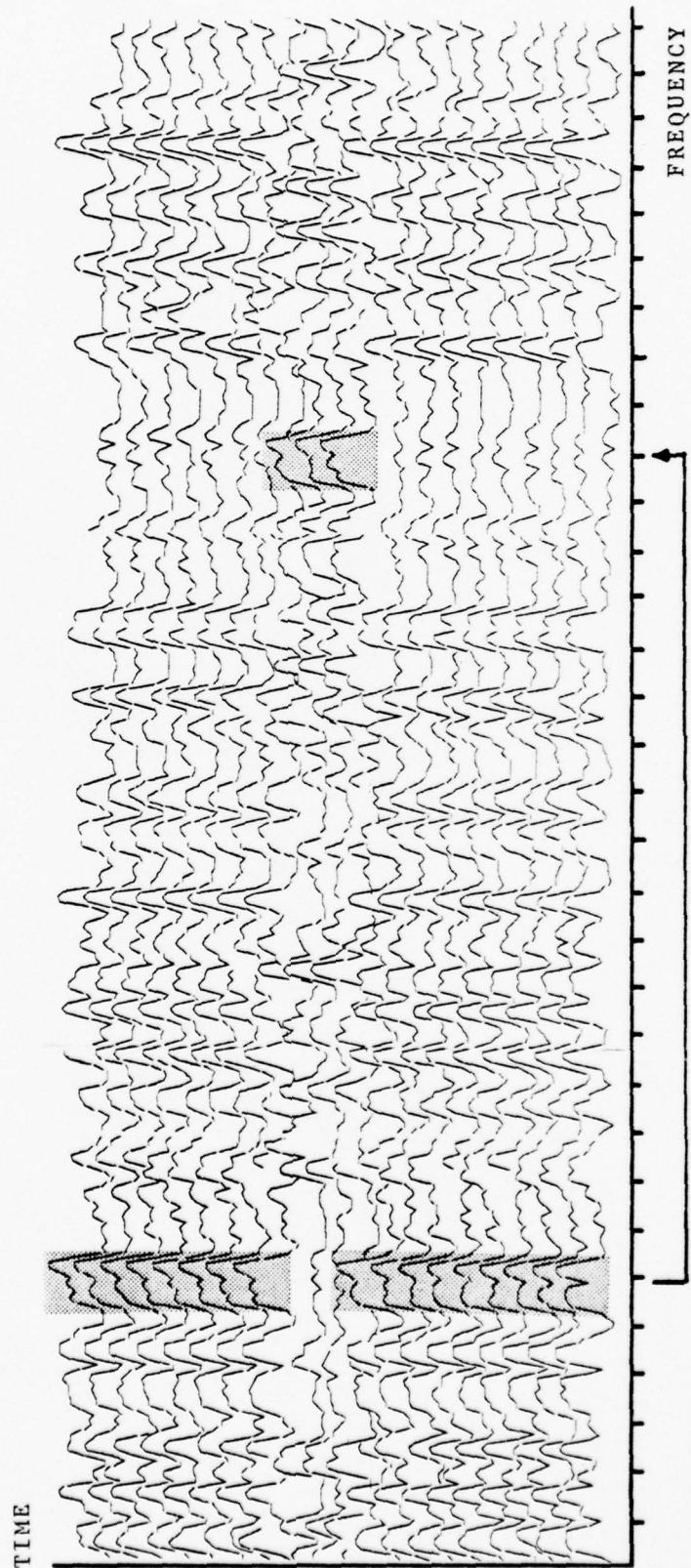
Figure 10 - SHIFTING EXAMPLE #1





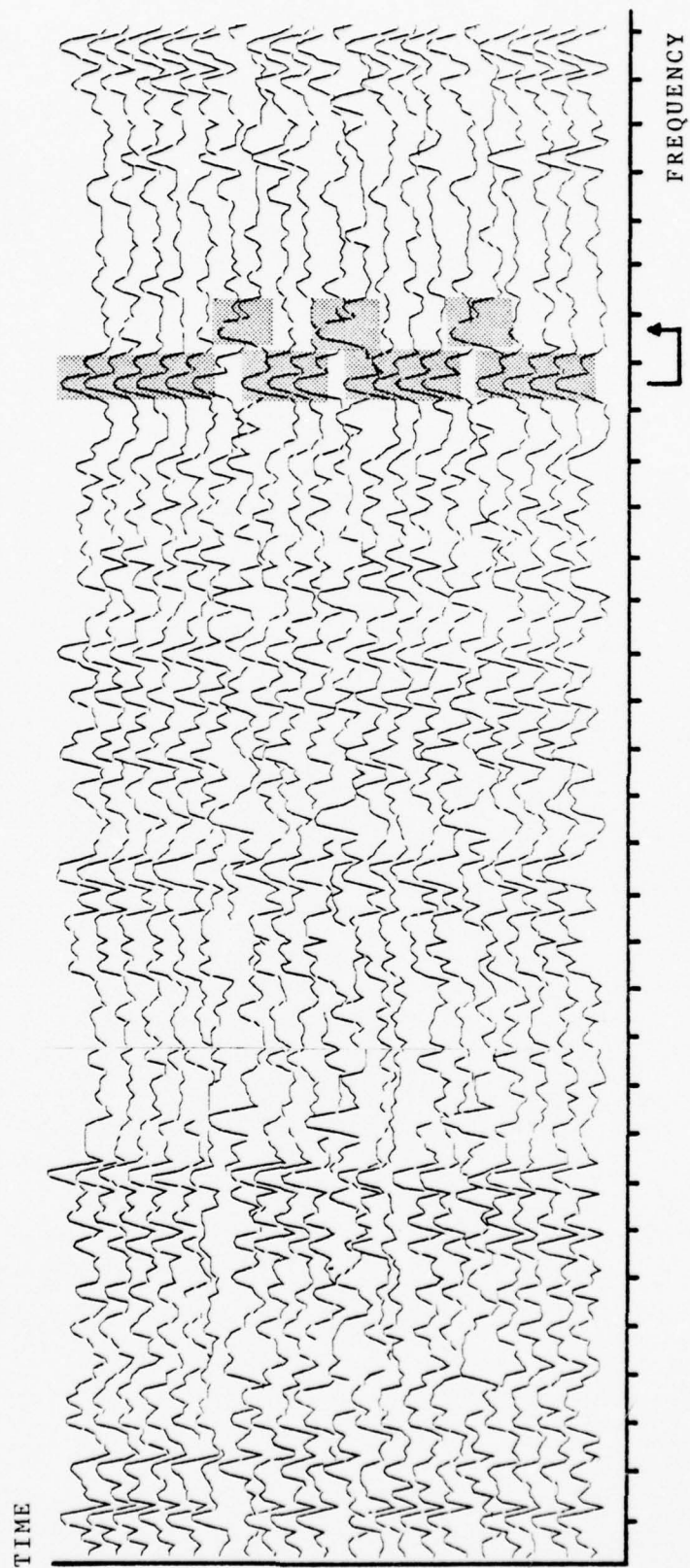
Set 139, Base Scan 3110, Base Freq 18 MHz, Base Bin 1

Figure 11 - SHIFTING EXAMPLE #2



Set 126, Base Scan 2940, Base Freq 8.2 MHz, Base Bin 1

Figure 12 - SHIFTING EXAMPLE #3

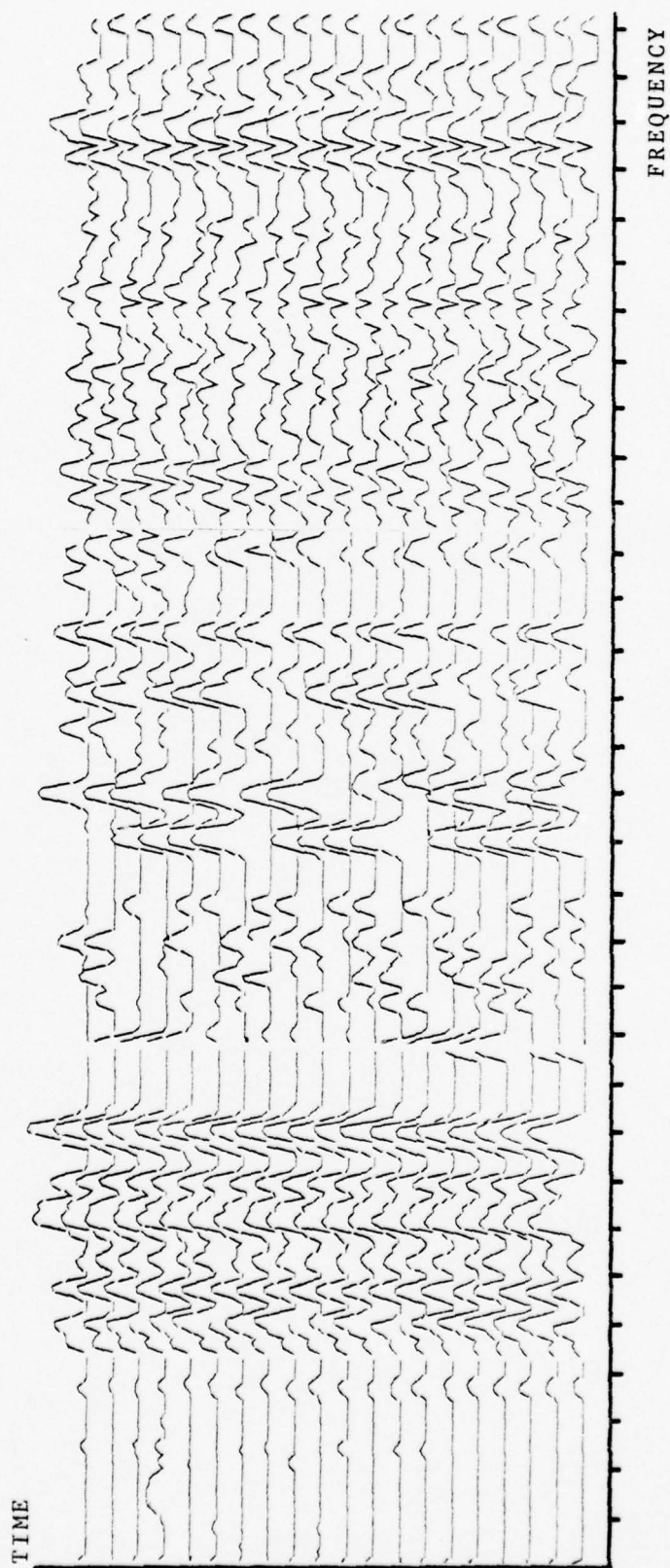


Set 67, Base Scan 2860, Base Freq 14 MHz, Base Bin 1

Figure 13 - SHIFTING EXAMPLE #4

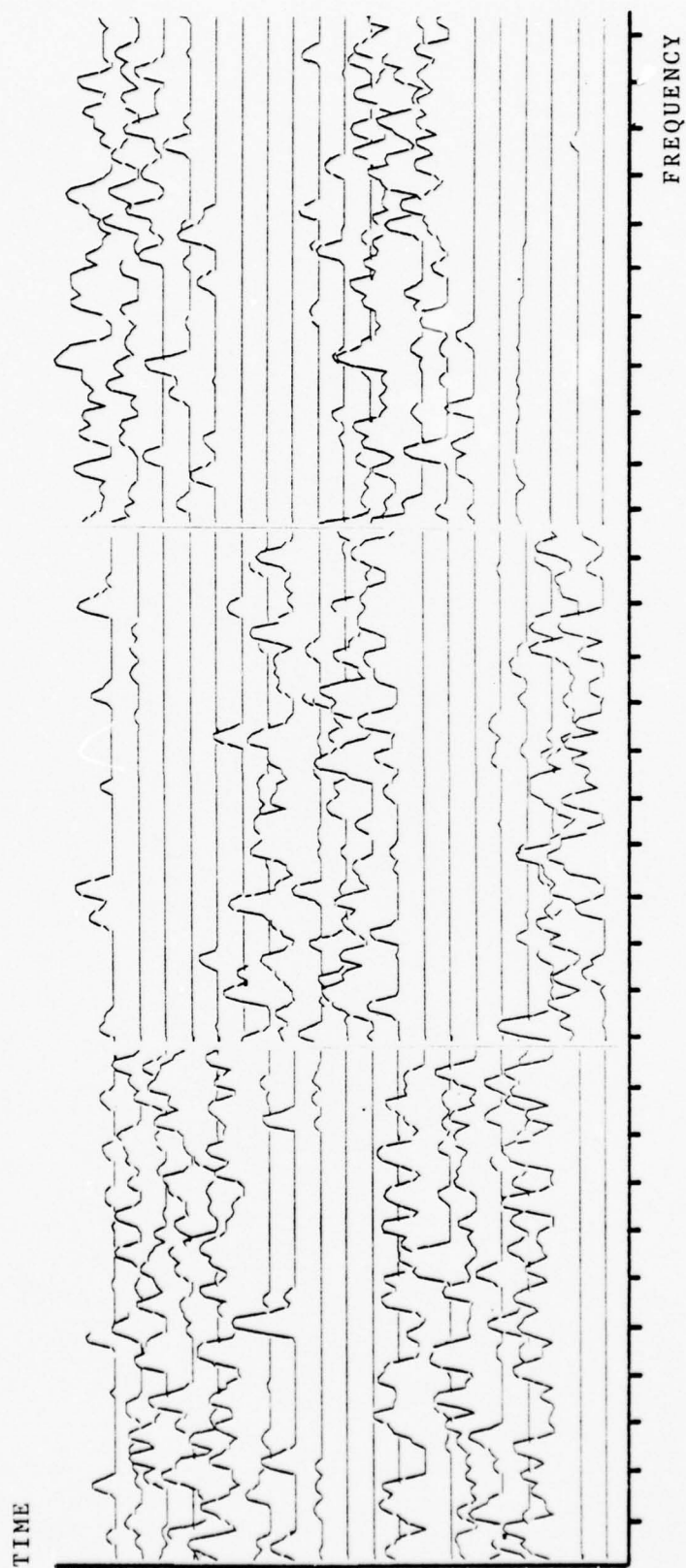


One final category for possible signal anomalies consists of five different phenomena each of which occurred, with one exception, only once in the thirty-four data sets. Figure 14 is an example wherein three different "anomalies" were present. (It should be noted that base scan = "various" for Figs. 14 and 15 means that each of the three sections of the waveforms in the two figures had different base scans and implies that this in no way detracts from the usefulness of the figures as examples of the affects in question.) Bins 1 through 40 and 83 through 98 exhibit a very high degree of signal attenuation not seen in normal data sets (i.e. data sets not found to have either a receiver malfunction or test signal present). Bins 41 through 87 exhibit normal signal characteristics. Bins 101 through 200 evidence a combination of unusual attenuation and normal signal activity, while bins 201 through 270 show either a general distortion of the signals present or a fairly high amplitude level of ambient noise and/or distorted signals plus noise. None of these phenomena could be explained by receiver malfunction, data card sequencing or special signal characteristics (i.e. test signal, etc.). Figure 15 shows a data set exhibiting no continuity of signal whatsoever. None of the signal "bumps" can be followed in a uniform manner as time progresses. The theory that a serious receiver system malfunction was the cause of the distortion was borne out by a call to the cognizant authority. This malfunction was also verified for data sets 25 and 54. The sawtooth effect seen at the middle, right hand side of Fig. 16 is a pattern not seen elsewhere either in this set or any of the other thirty-three sets analyzed. It shows wild fluctuations in seven adjacent amplitude points (2.8 kHz apart) in one scan, whereas the rest of the scan appears to be normal. No explanation for this phenomenon can be offered. Another unexpected anomaly was the two flat-topped signals, centered at bins 124 and 128,



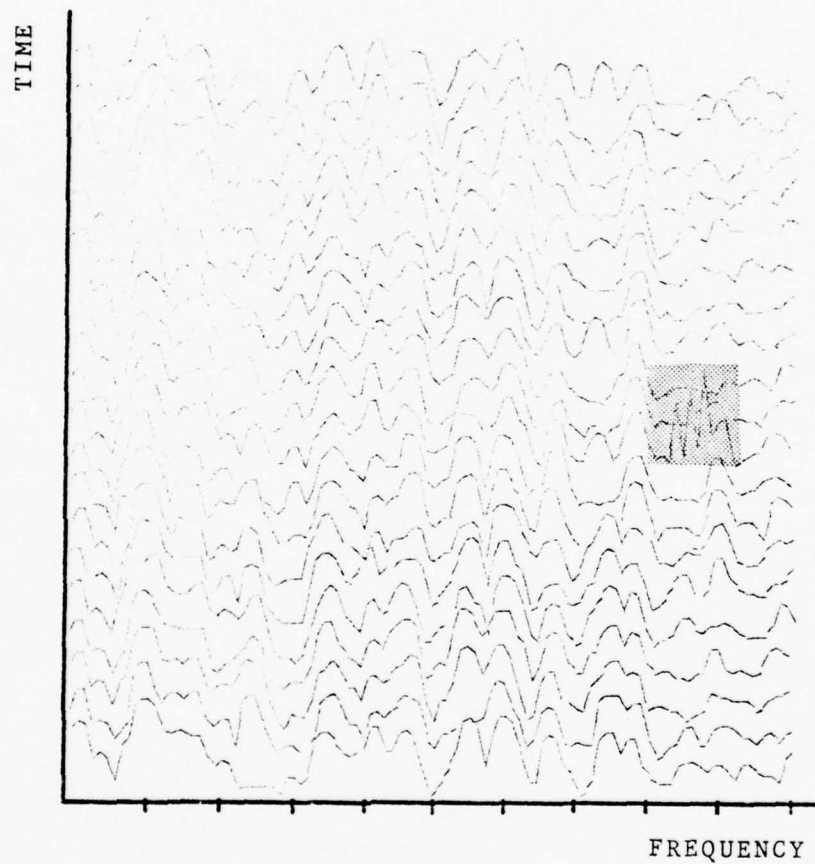
Set 91, Base Scan Various, Base Freq 13.6 MHz, Base Bin 1

Figure 14 - MULTIPLE ANOMALY EXAMPLE



Set 24, Base Scan Various, Base Freq 11 MHz, Base Bin 1

Figure 15 - EQUIPMENT MALFUNCTION EXAMPLE



Set 3, Base Scan 1815, Base Freq 3.2 MHz, Base Bin 100

Figure 16 - SAWTOOTH PATTERN EXAMPLE

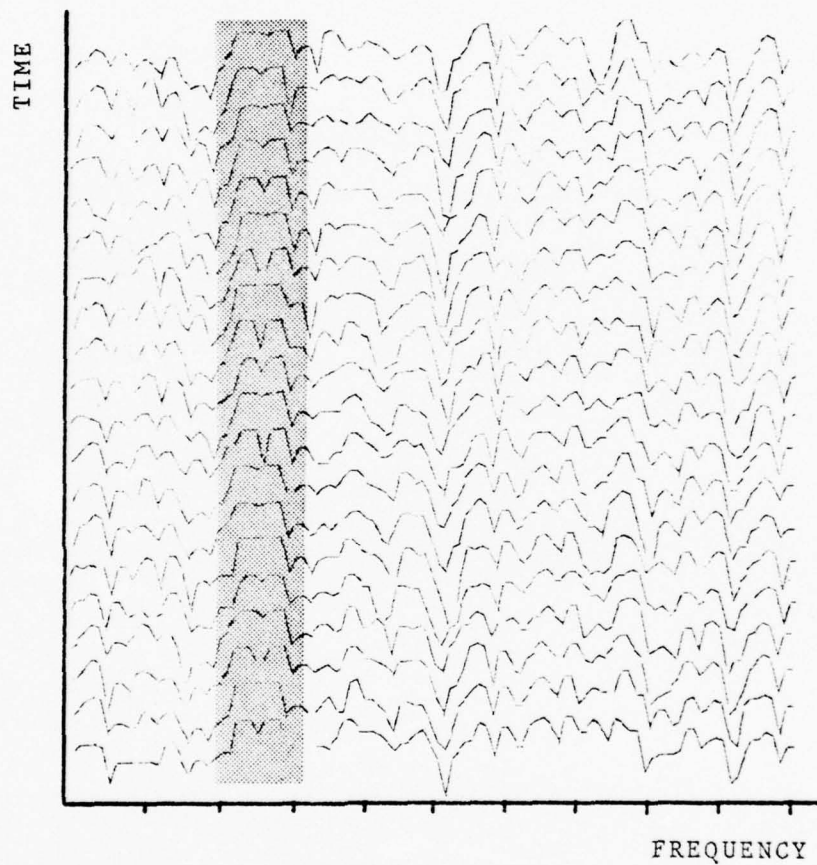
found in Fig. 17. It appears to be the result of some special attenuation applied to those frequency bins alone, because, as can be seen by the rather "large" signal centered on bin 178, other signals appear not to be affected. The additional attenuation applied to this set during reception, 10 dB, is lower than levels applied to other sets which were not similarly affected. The best phenomenon observed in this final category is found in Fig. 18. For some reason (other than the possibility of a different form of receiver malfunction than seen before) an otherwise normal data set lost total signal continuity across the entire frequency bandwidth with subsequent scans exhibiting a highly distorted nature. While this could not have been caused by a card sequencing problem, its source cannot be identified.

#### C. ANOMALY B ANOMALIES

The Anomaly B program provided a different perspective from which to observe the data sets since it presented two dissimilar plots on the screen at the same time. The lower traces consisted of five Anomaly A style three-dimensional plots, this time only eighty points (or bins) wide, while the upper five traces were the two-dimensional time vs. amplitude plots of bins selected from the traces below. It was felt that this different perspective would enhance the anomaly identification effort, that it did not was disappointing.

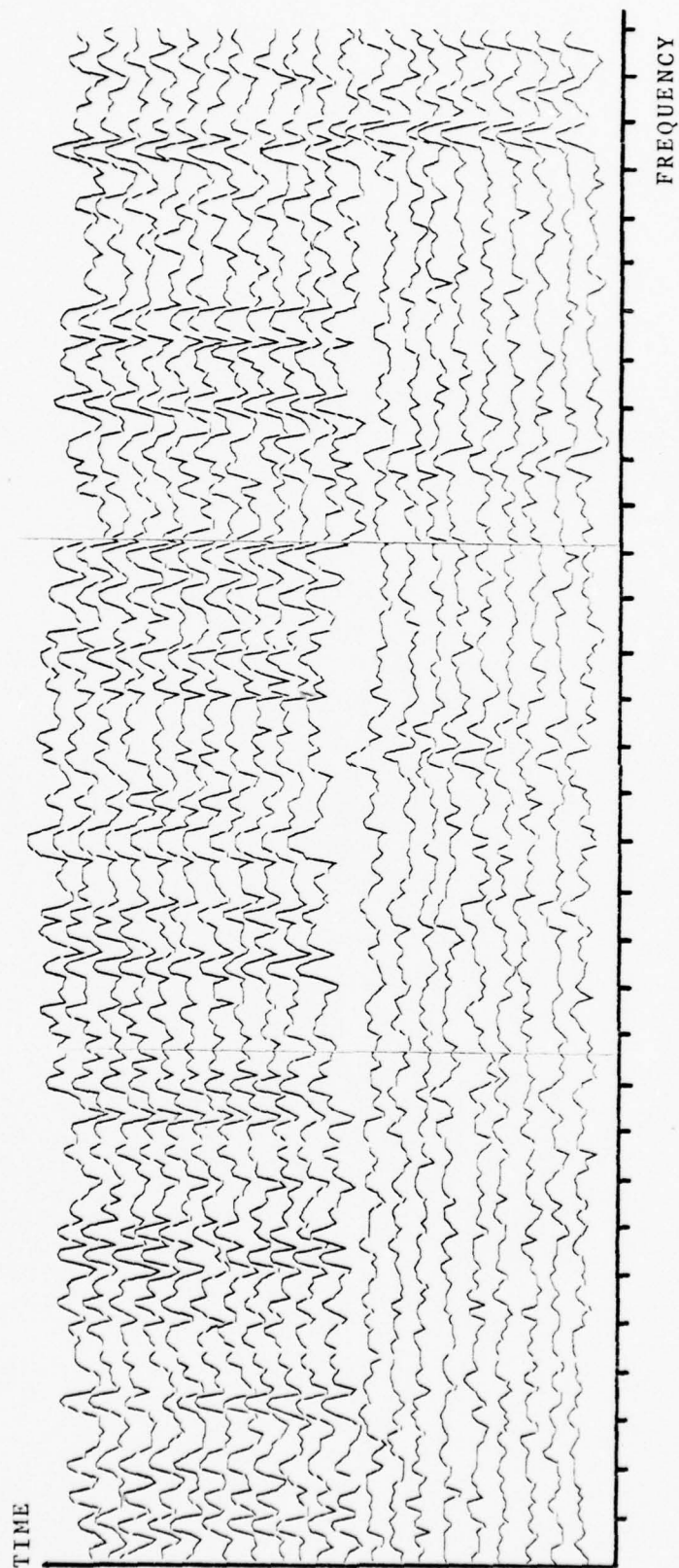
Of the eighteen data sets analyzed (3, 7, 16, 18, 20, 21, 33, 36, 37, 38, 40, 41, 51, 53, 61, 80, 125, and 139), Anomaly B proved useful in only two instances: (1) to provide a graphic presentation of the three signal types used in the Statistical Analysis Section of this paper; and





Set 16, Base Scan 932, Base Freq 9.7 MHz, Base Bin 100

Figure 17 - ATTENUATED SIGNALS EXAMPLE



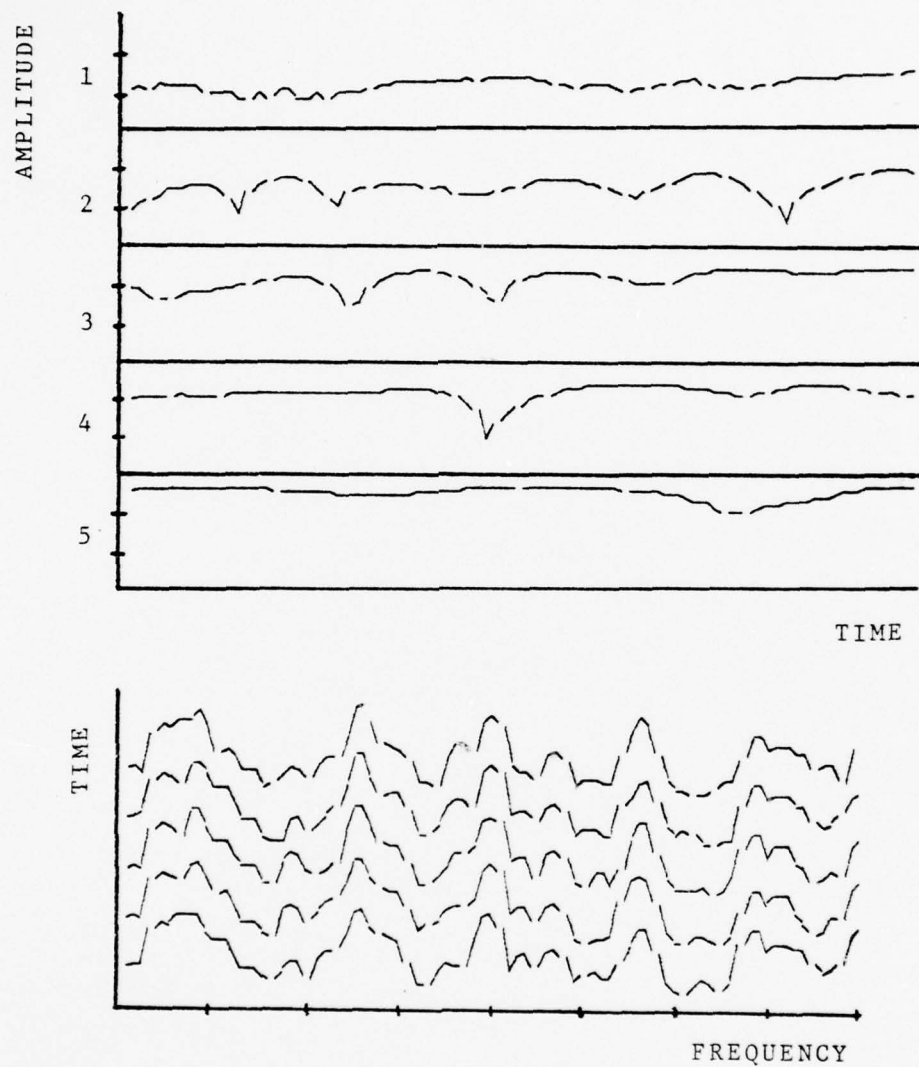
Set 148, Base Scan 210, Base Freq 10 MHz, Base Bin 1

Figure 18 - COMPLETE DISCONTINUITY EXAMPLE

(2) to illustrate one very interesting phenomenon which could not be seen by the Anomaly A presentation. As shown in Fig. 19 this phenomenon consists of an undulation in the amplitude of the five upper traces. This "lazy sinusoidal" variation appears to affect some signals more often than others. The term "lazy sinusoidal" should be used with care since it is not meant to imply that there is any strict periodicity to be found in the undulation or that the traces look exactly like sinusoids. However, many of the signals did evidence the more smooth (and, hence, sinusoidal) variation seen in trace one in the figure.

Although only relatively smooth waveforms are depicted in the figure, this effect was identified over a large range of signal types including those which keyed off and on; however, it was much easier to see this phenomenon on the smooth signals. This variation was seen in every data set analyzed although it occurred more frequently and noticeably in some than in others.

The cause of this undulation could be: (1) variations in transmitter output power levels; (2) receiver system processing; or (3) ionosphere-related phenomena including Faraday Rotation, Sporadic-E and fading.



Set 7, Base Scan 588, Base Bin 120

Figure 19 - AMPLITUDE UNDULATION EXAMPLE

#### IV. STATISTICAL ANALYSIS

##### A. DISCUSSION

In conjunction with the graphical analysis approach to identify signal anomalies attributable to ionospheric properties, an attempt was made to glean additional information from the BRIGHAM data by means of statistical algorithms; however, it should be noted that no attempt was made to identify anomalies by this approach. Rather, the programs MIN/MAX 1 and MIN/MAX 2 were developed in an effort to determine how often and by what amount (amplitude in decibels) both signal wavefronts (scans) and individual signals (bins or sets of bins) change. It was hoped that this new data might prove useful in the development of an algorithm to adjust the myriad sensitivity controls found on the swept-tuned receiving equipment used to acquire and record the BRIGHAM data. Although this effort has nothing directly to do with the signal analysis effort reported previously, it did take considerable time and effort to write the programs and create the desired data base. In addition, this evolution proved extremely helpful in the overall effort of understanding signal characteristics, the primary goal of this study.

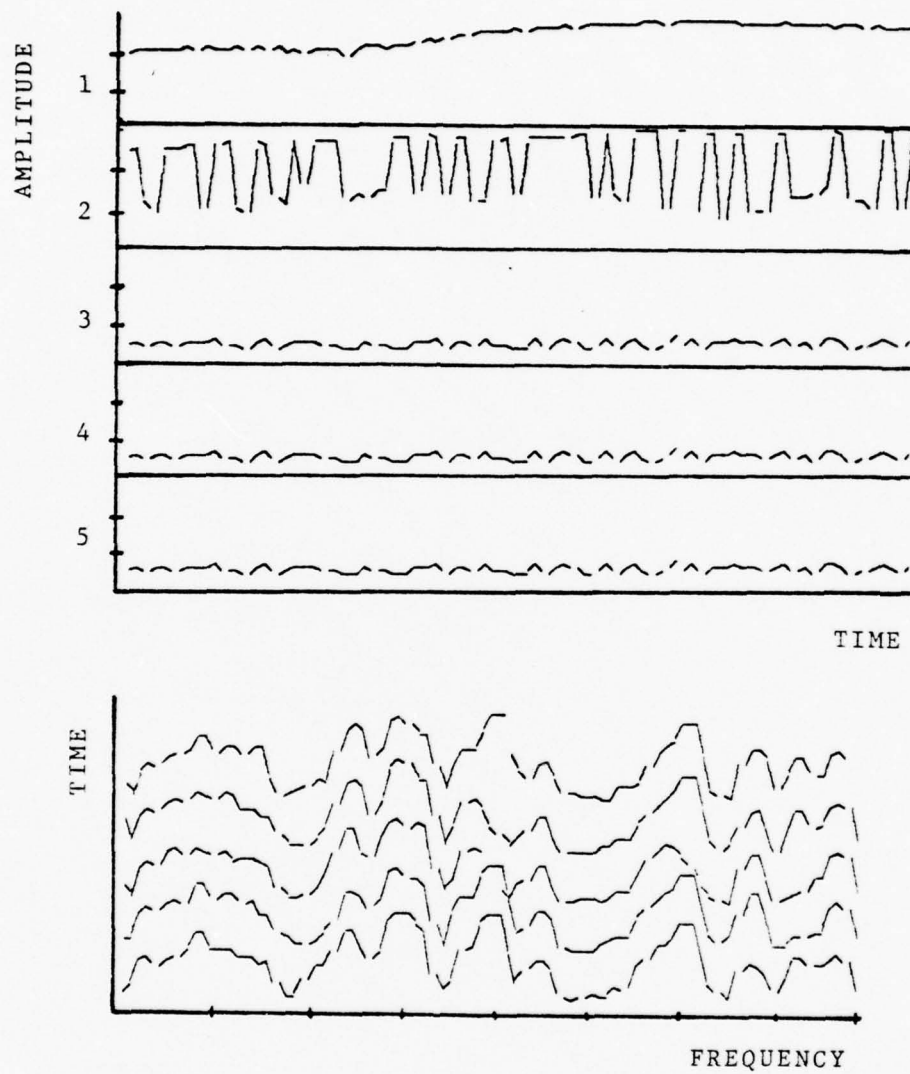
For the purposes of this inquiry, three different types of signals (one that stayed "on" through most of the signal duration, one that stayed "off" through most of the signal duration and one that appeared to key on and off throughout most of the signal duration) were chosen from data sets



which were collected at various times of the day. The quotation marks are used (here and throughout the rest of the paper) to imply a general trend noted over the life of the signal not some unvarying signal characteristic. Figure 20 is an Anomaly B graph plot presenting classic examples of the three signal types. The "ON" signal (exhibiting that "lazy sinusoidal" amplitude variation mentioned in the graphical analysis section) is trace 1, the "ON/OFF" signal is trace 2 and the "OFF" signal is trace 3. Traces 4 and 5 are merely copies of trace 3 to fill out the plot. A table giving all pertinent data on the twenty-four signals analyzed may be found in Fig. 21. In the figure, set frequency refers to the base frequency of the set when the recording was initiated while TOI means the time of interception for the data set. An attempt was made to analyze two signals from each of four different time categories (interesting from the ionosphere's standpoint), those being sunrise, noon, sunset and midnight. With one exception, set 53 - 2109LOCAL, this effort was realized.

#### B. STATISTICAL ANALYSIS PROGRAMS

The first generation algorithm developed, called MIN/MAX 1, provided for a scan-by-scan (down entire frequency bandwidths - cross sections of many signals - at fixed times) analysis of a variable number of scans within a given set. MIN/MAX 1 identified each of the peaks and valleys along the scans, chose the highest peak and lowest valley and computed the average peak and average valley heights. The quantization levels given on the data cards were changed to decibels and the amount of attenuation applied at the time of acquisition was added back in to give received signal levels accurately. MIN/MAX 1 proved to be of only small value since signal wavefronts vice signals themselves



Set 7, Base Scan 200, Base Bin 40

Figure 20 - THREE MIN/MAX SIGNAL TYPES

| SET | BIN | SIGNAL TYPE | SET FREQUENCY | SET TOI |
|-----|-----|-------------|---------------|---------|
| 3   | 136 | ON          | 03501 KHZ     | 0522Z   |
|     | 154 | ON/CFF      |               |         |
|     | 169 | OFF         |               |         |
| 7   | 8   | ON          | 11000 KHZ     | 1205Z   |
|     | 81  | ON/CFF      |               |         |
|     | 91  | OFF         |               |         |
| 20  | 265 | ON          | 04000 KHZ     | 1715Z   |
|     | 238 | ON/CFF      |               |         |
|     | 259 | OFF         |               |         |
| 21  | 150 | ON          | 05000 KHZ     | 0400Z   |
|     | 273 | ON/CFF      |               |         |
|     | 187 | OFF         |               |         |
| 53  | 19  | ON          | 07000 KHZ     | 2109Z   |
|     | 8   | ON/CFF      |               |         |
|     | 50  | OFF         |               |         |
| 80  | 82  | ON          | 10000 KHZ     | 0000Z   |
|     | 60  | ON/CFF      |               |         |
|     | 73  | OFF         |               |         |
| 81  | 4   | ON          | 04000 KHZ     | 0005Z   |
|     | 72  | ON/CFF      |               |         |
|     | 11  | OFF         |               |         |
| 126 | 57  | ON          | 03200 KHZ     | 1230Z   |
|     | 74  | ON/CFF      |               |         |
|     | 8   | OFF         |               |         |

Figure 21 - MIN/MAX SIGNAL PARAMETERS

were analyzed. A program listing for MIN/MAX 1 may be found at the end of this paper.

The next generation effort, tabbed MIN/MAX 2, focused on specific signals (the three varieties delineated in the discussion section above) and added a number of more valuable statistical features. Like its predecessor, MIN/MAX 2 identified each of the peaks and valleys, chose the highest peak and lowest valley and computed the average peak and average valley heights.

Its next feature was the determination of two different types of signal changes: (1) the comparison of sample point amplitudes with a sliding reference point to determine long-term changes in signal levels; and (2) the comparison of adjacent sample point amplitudes to determine short-term changes. The former was initiated with the bin 1 point as the reference point and all subsequent points compared with it until an amplitude was found which differed from the reference by a previously agreed upon number of decibels (for this test, 4, 6, 12 and 18 dB changes were used in succession). That point then became the reference point and the process continued for the entire 2.4 minute length of the signal. The number of such long-term changes and the elapsed time between each change were recorded. This data could then be used to attain the goal of this effort, the gauging of how often and by what amount the various signal types changed.

A further refinement of the procedure was the creation of amplitude histograms of the elapsed times between the changes to illustrate the effect that increasing the level of decibel fluctuation which constituted a change had on both the frequency of changes and the distribution of elapsed times. Since the receiver sampling rate was 25 Hz, the smallest elapsed time possible between X dB fluctuations

was 0.04 seconds. A brief analysis of the first set of elapsed times led to the division of the time line (abscissa) into twenty-one time bins with the inclusive boundaries given in Fig. 22 and labeled N1 through N21. As a further refinement, bins N1, N2 and the first segment of N3 were divided into individual 0.04 second bins labeled N1-1 through N1-7, N2-1 through N2-3 and N3-1 respectively. The two histograms gave an excellent perspective from which to watch the changes in signal characteristic as the amount of decibel fluctuation tested was stepped from 4 to 6 to 12 and, finally, to 18 dB.

The final output of MIN/MAX 2 was, in addition to the peak and valley statistics mentioned above, a listing of the number of long-term changes that took place in each of the thirty-seven time bins of interest, the percentage of the number of changes under each time bin as compared with the total number of changes. (this allowed for a more valid comparison of the over-all change picture when an increase in decibel deviation required resulted in fewer changes tabulated in the bins), the total number of long-term changes (called NUM in the output) and the total number of changes in adjacent sample points (the short-term changes mentioned above). In addition, the mean and standard deviation for the elapsed times between long-term changes were computed. A listing for MIN/MAX 2 may be found at the end of this paper.

### C. OBSERVATIONS AND CONCLUSIONS

There were a number of surprises which resulted from the initial computer output from MIN/MAX 2. First, the high number of both long- and short-term changes identified was not expected. Out of the possible 3597 changes (there were



| TIME BIN | START | END   |
|----------|-------|-------|
| N1       | 0.04  | 0.28  |
| N2       | 0.32  | 0.60  |
| N3       | 0.64  | 0.96  |
| N4       | 1.00  | 1.28  |
| N5       | 1.32  | 1.60  |
| N6       | 1.64  | 1.96  |
| N7       | 2.00  | 2.28  |
| N8       | 2.32  | 2.60  |
| N9       | 2.64  | 2.96  |
| N10      | 3.00  | 3.28  |
| N11      | 3.32  | 3.60  |
| N12      | 3.64  | 3.96  |
| N13      | 4.00  | 4.28  |
| N14      | 4.32  | 4.60  |
| N15      | 4.64  | 4.96  |
| N16      | 5.00  | 7.46  |
| N17      | 7.50  | 9.96  |
| N18      | 10.00 | 14.96 |
| N19      | 15.00 | 19.96 |
| N20      | 20.00 | 29.96 |
| N21      | 30.00 | NONE  |
| N1-1     | 0.02  | 0.06  |
| N1-2     | 0.06  | 0.10  |
| N1-3     | 0.10  | 0.14  |
| N1-4     | 0.14  | 0.18  |
| N1-5     | 0.18  | 0.22  |
| N1-6     | 0.22  | 0.26  |
| N1-7     | 0.26  | 0.30  |
| N2-1     | 0.30  | 0.34  |
| N2-2     | 0.34  | 0.38  |
| N2-3     | 0.38  | 0.42  |
| N2-4     | 0.42  | 0.46  |
| N2-5     | 0.46  | 0.50  |
| N2-6     | 0.50  | 0.54  |
| N2-7     | 0.54  | 0.58  |
| N2-8     | 0.58  | 0.62  |
| N3-1     | 0.62  | 0.66  |

NOTE: START AND END FIGURES ARE IN SECCNCS.

Figure 22 - HISTOGRAM TIME BIN PARAMETERS

at most that many scans, or sample points, available for each signal of interest) the number of changes noted in some cases reached as high as 2000 for the lower decibel fluctuation levels. Second, the elapsed time histograms tabulated showed a marked tendency to be heavily damped exponentials in nature with the 0.04 second bin (N1-1) having the highest number of occurrences throughout. And third, there was a high degree of overlap between the statistical characteristics generated for the three signal types chosen indicating that there was no absolute way to categorize a signal as "ON", "ON/OFF" or "OFF" merely by looking at its statistics. What was expected (and did occur) was that, as the number of decibels used for comparison increased, the exponential distributions "flowed" to the right indicating greater elapsed times between larger decibel fluctuations.

Figures 23 - 29 represent the bulk of the meaningful data garnered from the MIN/MAX 2 application to the twenty-four signals of interest. In speaking of the characteristics which differentiate the three arbitrarily chosen and defined signal types, Figs. 23 - 28 provide those statistics which can be of value in coming to a logical conclusion concerning their differences. As would be expected from "ON/OFF" signals, they showed a greater difference between both average peak and valley values and between "maxmax" and "minmin" values than did the other two, implying more signal level fluctuation. The "OFF" signals consistently showed the smallest fluctuations as would be expected from a series of either highly decayed signals or high but fluctuating ambient noise. Based on these statistics alone it would be nearly impossible to distinguish with a high degree of certainty between an "ON" and an "ON/OFF" signal given only the parameters in those figures. Figure 29 provides both a summary of the data concerning the number of changes tabulated for each decibel

| SET | BIN | PEAK  | VALLEY | MAXMAX | MINMIN |
|-----|-----|-------|--------|--------|--------|
| 3   | 136 | 54.40 | 46.78  | 58     | 8      |
| 7   | 8   | 56.74 | 52.02  | 62     | 34     |
| 20  | 265 | 45.65 | 39.65  | 54     | 24     |
| 21  | 150 | 55.44 | 49.19  | 62     | 20     |
| 53  | 19  | 55.97 | 52.16  | 66     | 28     |
| 60  | 82  | 57.83 | 53.54  | 68     | 22     |
| 61  | 4   | 68.81 | 60.75  | 70     | 10     |
| 126 | 57  | 43.52 | 38.61  | 52     | 0      |

| PEAK AVG | VALLEY AVG | PVR       | PVA  | MMR   | MMA   |
|----------|------------|-----------|------|-------|-------|
| 54.54    | 49.09      | 3.81-8.06 | 5.46 | 28-60 | 43.25 |

KEY:      PEAK = AVERAGE OF ALL MAX PTS IN EACH BIN (SIGNAL)  
          VALLEY = AVERAGE OF ALL MIN PTS IN EACH BIN (SIGNAL)  
          MAXMAX = LARGEST PEAK VALUE  
          MINMIN = SMALLEST VALLEY VALUE  
          PVR = RANGE OF DIFFERENCES BETWEEN PEAK & VALLEY  
          PVA = AVERAGE DIFFERENCE BETWEEN PEAK & VALLEY  
          MMR = RANGE OF DIFFERENCES BETWEEN MAXMAX & MINMIN  
          MMA = AVERAGE DIFFERENCE BETWEEN MAXMAX & MINMIN  
          PEAK AVG = AVERAGE OF ALL PEAKS FOR "ON" SIGNALS  
          VALLEY AVG = AVERAGE OF ALL VALLEYS FOR "ON" SIGNALS

Figure 23 - "ON" SIGNAL PEAK-VALLEY STATISTICS

| SET | BIN | PEAK  | VALLEY | MAXMAX | MINMIN |
|-----|-----|-------|--------|--------|--------|
| 3   | 154 | 52.49 | 44.69  | 62     | 8      |
| 7   | 81  | 42.96 | 16.57  | 66     | 8      |
| 20  | 238 | 51.69 | 41.24  | 62     | 24     |
| 21  | 273 | 57.00 | 49.16  | 72     | 20     |
| 53  | 8   | 55.96 | 48.15  | 64     | 26     |
| 80  | 60  | 59.84 | 54.30  | 70     | 18     |
| 81  | 72  | 40.82 | 30.44  | 60     | 10     |
| 126 | 74  | 21.19 | 16.11  | 30     | 0      |

| PEAK AVG | VALLEY AVG | PVR        | PVA   | MMR   | MMA   |
|----------|------------|------------|-------|-------|-------|
| 47.74    | 37.58      | 5.08-26.57 | 10.18 | 30-58 | 46.50 |

KEY:     PEAK = AVERAGE OF ALL MAX PTS IN EACH BIN (SIGNAL)  
          VALLEY = AVERAGE OF ALL MIN PTS IN EACH BIN (SIGNAL)  
          MAXMAX = LARGEST PEAK VALUE  
          MINMIN = SMALLEST VALLEY VALUE  
          PVR = RANGE OF DIFFERENCES BETWEEN PEAK & VALLEY  
          PVA = AVERAGE DIFFERENCE BETWEEN PEAK & VALLEY  
          MMR = RANGE OF DIFFERENCES BETWEEN MAXMAX & MINMIN  
          MMA = AVERAGE DIFFERENCE BETWEEN MAXMAX & MINMIN  
          PEAK AVG = AVERAGE OF ALL PEAKS FOR "ON/OFF" SIGNALS  
          VALLEY AVG = AVERAGE OF ALL VALLEYS FOR "ON/OFF" SIGNALS

Figure 24 - "ON/OFF" SIGNAL PEAK-VALLEY STATISTICS

| SET | BIN | PEAK  | VALLEY | MAXMAX | MINMIN |
|-----|-----|-------|--------|--------|--------|
| 3   | 169 | 19.19 | 13.57  | 46     | 8      |
| 7   | 91  | 11.33 | 8.05   | 26     | 8      |
| 20  | 259 | 13.76 | 8.36   | 26     | 4      |
| 21  | 187 | 47.97 | 41.14  | 56     | 20     |
| 53  | 50  | 28.26 | 22.69  | 38     | 16     |
| 80  | 73  | 18.42 | 12.65  | 24     | 10     |
| 81  | 11  | 25.02 | 17.77  | 54     | 10     |
| 126 | 8   | 14.69 | 10.64  | 36     | 0      |

| PEAK AVG | VALLEY AVG | PVR       | PVA  | MMR   | MMA   |
|----------|------------|-----------|------|-------|-------|
| 22.33    | 16.88      | 3.28-7.25 | 5.47 | 14-44 | 28.75 |

KEY:     PEAK = AVERAGE OF ALL MAX PTS IN EACH BIN (SIGNAL)  
          VALLEY = AVERAGE OF ALL MIN PTS IN EACH BIN (SIGNAL)  
          MAXMAX = LARGEST PEAK VALUE  
          MINMIN = SMALLEST VALLEY VALUE  
          PVR = RANGE OF DIFFERENCES BETWEEN PEAK & VALLEY  
          PVA = AVERAGE DIFFERENCE BETWEEN PEAK & VALLEY  
          MMR = RANGE OF DIFFERENCES BETWEEN MAXMAX & MINMIN  
          MMA = AVERAGE DIFFERENCE BETWEEN MAXMAX & MINMIN  
          PEAK AVG = AVERAGE OF ALL PEAKS FOR "OFF" SIGNALS  
          VALLEY AVG = AVERAGE OF ALL VALLEYS FOR "OFF" SIGNALS

Figure 25 - "OFF" SIGNAL PEAK-VALLEY STATISTICS



| SET | BIN | DB | NUM  | ADJ  | N1 | N2 | N3 | N1-1 | N1-2 | N1-3 | N1-4 |
|-----|-----|----|------|------|----|----|----|------|------|------|------|
| 3   | 136 | 4  | 1233 | 1226 | 94 | 4  | 1  | 50   | 20   | 10   | 7    |
|     |     | 6  | 636  | 649  | 87 | 5  | 4  | 44   | 18   | 9    | 7    |
|     |     | 12 | 123  | 135  | 67 | 5  | 6  |      |      |      |      |
|     |     | 18 | 25   | 27   | 56 | 4  | 4  |      |      |      |      |
| 7   | 8   | 4  | 1417 | 1406 | 95 | 4  | 1  | 48   | 24   | 9    | 7    |
|     |     | 6  | 515  | 539  | 81 | 9  | 4  | 34   | 19   | 10   | 7    |
|     |     | 12 | 29   | 15   | 52 | 7  | 3  |      |      |      |      |
|     |     | 18 | 5    | 5    | 60 | 0  | 0  |      |      |      |      |
| 20  | 265 | 4  | 1496 | 1519 | 95 | 4  | 1  | 55   | 20   | 10   | 5    |
|     |     | 6  | 844  | 887  | 88 | 6  | 3  | 45   | 21   | 10   | 5    |
|     |     | 12 | 181  | 180  | 67 | 7  | 9  |      |      |      |      |
|     |     | 18 | 0    | 0    | 0  | 0  | 0  |      |      |      |      |
| 21  | 150 | 4  | 1442 | 1433 | 96 | 3  | 1  | 54   | 21   | 10   | 5    |
|     |     | 6  | 916  | 938  | 93 | 3  | 2  | 51   | 21   | 9    | 7    |
|     |     | 12 | 175  | 222  | 36 | 3  | 1  |      |      |      |      |
|     |     | 18 | 19   | 27   | 47 | 0  | 0  |      |      |      |      |
| 53  | 19  | 4  | 329  | 208  | 68 | 12 | 8  | 13   | 21   | 5    | 5    |
|     |     | 6  | 192  | 113  | 56 | 15 | 7  | 6    | 21   | 3    | 2    |
|     |     | 12 | 61   | 30   | 28 | 11 | 13 |      |      |      |      |
|     |     | 18 | 14   | 2    | 7  | 7  | 29 |      |      |      |      |
| 80  | 82  | 4  | 898  | 929  | 88 | 8  | 3  | 45   | 20   | 9    | 6    |
|     |     | 6  | 353  | 324  | 73 | 13 | 4  | 37   | 14   | 6    | 6    |
|     |     | 12 | 44   | 34   | 43 | 14 | 7  |      |      |      |      |
|     |     | 18 | 6    | 7    | 50 | 0  | 0  |      |      |      |      |
| 81  | 4   | 4  | 1932 | 1932 | 98 | 2  | 0  | 62   | 20   | 9    | 3    |
|     |     | 6  | 1350 | 1340 | 94 | 5  | 1  | 48   | 22   | 11   | 6    |
|     |     | 12 | 281  | 329  | 68 | 10 | 11 |      |      |      |      |
|     |     | 18 | 52   | 56   | 50 | 10 | 13 |      |      |      |      |
| 126 | 57  | 4  | 334  | 61   | 58 | 19 | 12 | 9    | 12   | 10   | 7    |
|     |     | 6  | 176  | 14   | 43 | 24 | 9  | 3    | 9    | 5    | 8    |
|     |     | 12 | 59   | 2    | 27 | 15 | 5  |      |      |      |      |
|     |     | 18 | 19   | 2    | 11 | 11 | 11 |      |      |      |      |

KEY: DB = DB CHANGE TESTED  
 NUM = NUMBER OF LONG-TERM CHANGES  
 ADJ = NUMBER OF SHORT-TERM (ADJACENT POINT) CHANGES  
 N\_ = PERCENTAGE OF LONG-TERM CHANGES IN TIME BIN N\_\_

Figure 26 - "ON" SIGNAL ELAPSED TIME STATISTICS

| SET | BIN | DB | NUM  | ADJ  | N1  | N2 | N3 | N1-1 | N1-2 | N1-3 | N1-4 |
|-----|-----|----|------|------|-----|----|----|------|------|------|------|
| 3   | 154 | 4  | 2101 | 2130 | 100 | 0  | 0  | 60   | 24   | 9    | 5    |
|     |     | 6  | 1325 | 1357 | 95  | 5  | 0  | 41   | 22   | 12   | 10   |
|     |     | 12 | 252  | 215  | 65  | 15 | 4  |      |      |      |      |
|     |     | 18 | 21   | 34   | 48  | 5  | 0  |      |      |      |      |
| 7   | 81  | 4  | 2012 | 1984 | 100 | 0  | 0  | 62   | 19   | 4    | 11   |
|     |     | 6  | 1675 | 1653 | 99  | 1  | 0  | 52   | 21   | 4    | 16   |
|     |     | 12 | 1225 | 1214 | 96  | 3  | 0  |      |      |      |      |
|     |     | 18 | 1150 | 1147 | 96  | 3  | 0  |      |      |      |      |
| 20  | 238 | 4  | 2162 | 2188 | 100 | 0  | 0  | 56   | 28   | 12   | 2    |
|     |     | 6  | 1513 | 1480 | 97  | 2  | 0  | 39   | 25   | 23   | 5    |
|     |     | 12 | 324  | 291  | 59  | 20 | 10 |      |      |      |      |
|     |     | 18 | 36   | 27   | 36  | 3  | 3  |      |      |      |      |
| 21  | 273 | 4  | 1573 | 1482 | 97  | 3  | 0  | 49   | 24   | 11   | 7    |
|     |     | 6  | 939  | 873  | 87  | 9  | 3  | 37   | 21   | 11   | 8    |
|     |     | 12 | 322  | 254  | 75  | 9  | 5  |      |      |      |      |
|     |     | 18 | 131  | 115  | 84  | 6  | 5  |      |      |      |      |
| 53  | 8   | 4  | 1515 | 1526 | 96  | 3  | 1  | 53   | 22   | 11   | 5    |
|     |     | 6  | 1059 | 1113 | 93  | 4  | 2  | 50   | 21   | 12   | 4    |
|     |     | 12 | 283  | 374  | 80  | 5  | 4  |      |      |      |      |
|     |     | 18 | 60   | 80   | 53  | 3  | 2  |      |      |      |      |
| 80  | 60  | 4  | 1430 | 1434 | 95  | 4  | 1  | 44   | 30   | 11   | 4    |
|     |     | 6  | 660  | 818  | 85  | 9  | 2  | 36   | 27   | 7    | 5    |
|     |     | 12 | 15   | 25   | 20  | 7  | 0  |      |      |      |      |
|     |     | 18 | 4    | 1    | 25  | 0  | 0  |      |      |      |      |
| 81  | 72  | 4  | 2312 | 2322 | 100 | 0  | 0  | 67   | 20   | 7    | 3    |
|     |     | 6  | 1647 | 1645 | 97  | 2  | 0  | 52   | 25   | 10   | 5    |
|     |     | 12 | 615  | 553  | 82  | 9  | 4  |      |      |      |      |
|     |     | 18 | 216  | 209  | 70  | 12 | 6  |      |      |      |      |
| 126 | 74  | 4  | 1277 | 1245 | 94  | 5  | 1  | 49   | 20   | 10   | 6    |
|     |     | 6  | 577  | 592  | 81  | 11 | 4  | 38   | 15   | 7    | 9    |
|     |     | 12 | 80   | 69   | 49  | 20 | 9  |      |      |      |      |
|     |     | 18 | 16   | 8    | 31  | 13 | 0  |      |      |      |      |

KEY: DB = DB CHANGE TESTED

NUM = NUMBER OF LONG-TERM CHANGES

ADJ = NUMBER OF SHORT-TERM (ADJACENT POINT) CHANGES

N\_ = PERCENTAGE OF LONG-TERM CHANGES IN TIME BIN N\_

Figure 27 - "ON/OFF" SIGNAL ELAPSED TIME STATISTICS

| SET | BIN | DB | NUM  | ADJ  | N1 | N2 | N3 | N1-1 | N1-2 | N1-3 | N1-4 |
|-----|-----|----|------|------|----|----|----|------|------|------|------|
| 3   | 169 | 4  | 1630 | 1609 | 97 | 3  | 0  | 51   | 23   | 11   | 5    |
|     |     | 6  | 802  | 748  | 85 | 9  | 3  | 33   | 23   | 11   | 6    |
|     |     | 12 | 42   | 37   | 55 | 10 | 12 |      |      |      |      |
|     |     | 18 | 4    | 4    | 50 | 0  | 25 |      |      |      |      |
| 7   | 91  | 4  | 628  | 620  | 79 | 12 | 4  | 46   | 13   | 7    | 5    |
|     |     | 6  | 146  | 146  | 66 | 8  | 5  | 38   | 15   | 2    | 5    |
|     |     | 12 | 2    | 2    | 50 | 0  | 0  |      |      |      |      |
|     |     | 18 | 2    | 2    | 50 | 0  | 0  |      |      |      |      |
| 20  | 259 | 4  | 1593 | 1594 | 97 | 3  | 0  | 51   | 21   | 11   | 6    |
|     |     | 6  | 763  | 716  | 82 | 12 | 4  | 33   | 19   | 13   | 6    |
|     |     | 12 | 26   | 21   | 38 | 15 | 15 |      |      |      |      |
|     |     | 18 | 0    | 0    | 0  | 0  | 0  |      |      |      |      |
| 21  | 187 | 4  | 1651 | 1655 | 96 | 3  | 1  | 57   | 19   | 10   | 5    |
|     |     | 6  | 1008 | 1009 | 88 | 9  | 2  | 45   | 19   | 10   | 7    |
|     |     | 12 | 226  | 208  | 58 | 14 | 8  |      |      |      |      |
|     |     | 18 | 20   | 38   | 45 | 10 | 10 |      |      |      |      |
| 53  | 50  | 4  | 1690 | 1679 | 98 | 2  | 0  | 52   | 23   | 10   | 6    |
|     |     | 6  | 827  | 818  | 86 | 8  | 4  | 35   | 23   | 10   | 7    |
|     |     | 12 | 56   | 21   | 41 | 16 | 9  |      |      |      |      |
|     |     | 18 | 2    | 0    | 0  | 0  | 0  |      |      |      |      |
| 80  | 73  | 4  | 1785 | 1792 | 98 | 2  | 0  | 54   | 23   | 10   | 6    |
|     |     | 6  | 863  | 883  | 85 | 10 | 3  | 34   | 22   | 11   | 8    |
|     |     | 12 | 0    | 0    | 0  | 0  | 0  |      |      |      |      |
|     |     | 18 | 0    | 0    | 0  | 0  | 0  |      |      |      |      |
| 81  | 11  | 4  | 2077 | 2089 | 99 | 1  | 0  | 63   | 20   | 9    | 5    |
|     |     | 6  | 1267 | 1246 | 93 | 6  | 1  | 45   | 20   | 11   | 7    |
|     |     | 12 | 156  | 130  | 58 | 12 | 8  |      |      |      |      |
|     |     | 18 | 19   | 15   | 47 | 11 | 5  |      |      |      |      |
| 126 | 8   | 4  | 934  | 912  | 87 | 10 | 3  | 38   | 20   | 10   | 6    |
|     |     | 6  | 313  | 249  | 60 | 15 | 11 | 20   | 12   | 7    | 5    |
|     |     | 12 | 28   | 5    | 11 | 14 | 11 |      |      |      |      |
|     |     | 18 | 2    | 2    | 50 | 0  | 0  |      |      |      |      |

KEY: DB = DB CHANGE TESTED  
 NUM = NUMBER OF LONG-TERM CHANGES  
 ADJ = NUMBER OF SHORT-TERM (ADJACENT POINT) CHANGES  
 N\_ = PERCENTAGE OF LONG-TERM CHANGES IN TIME BIN N\_

Figure 28 - "OFF" SIGNAL ELAPSED TIME STATISTICS

### "ON" SIGNAL STATISTICS

| dB | NUM RANGE | NUM AVG | ADJ RANGE | ADJ AVG |
|----|-----------|---------|-----------|---------|
| 4  | 329-1932  | 1135    | 61-1932   | 1089    |
| 6  | 178-1350  | 623     | 14-1340   | 600     |
| 12 | 29- 281   | 119     | 2- 329    | 118     |
| 18 | 0- 52     | 18      | 0- 56     | 16      |

### "ON/OFF" SIGNAL STATISTICS

| dB | NUM RANGE | NUM AVG | ADJ RANGE | ADJ AVG |
|----|-----------|---------|-----------|---------|
| 4  | 1277-2312 | 1798    | 1245-2322 | 1789    |
| 6  | 577-1675  | 1174    | 592-1653  | 1192    |
| 12 | 15-1225   | 390     | 25-1214   | 374     |
| 18 | 4-1150    | 204     | 1-1147    | 202     |

### "OFF" SIGNAL STATISTICS

| dB | NUM RANGE | NUM AVG | ADJ RANGE | ADJ AVG |
|----|-----------|---------|-----------|---------|
| 4  | 628-2077  | 1498    | 620-2089  | 1494    |
| 6  | 146-1267  | 749     | 146-1246  | 726     |
| 12 | 0- 226    | 64      | 0- 208    | 64      |
| 18 | 0- 20     | 6       | 0- 38     | 8       |

Figure 29 - OVER-ALL dB VS. CHANGE DATA

comparison level and a general means of distinguishing between the three types of signals. Although there are definite differences between the average figures for the various dB levels and some differences in the ranges of values, the overlap encountered in the ranges makes signal differentiation by this means risky. In short, what distinguished the "ON" from the "ON/OFF" and "OFF" signals was thoroughly subjective and only loosely corroborated by the statistics generated.

Additional information can be retrieved from Figs. 26 - 28 which provide the number of changes (both long- and short-term) found when the decibel differential was "walked" from 4 to 18 dB and the percentage of long-term changes which fell into the most meaningful of the thirty-seven histogram bins (for elapsed times between long-term changes). As is clearly shown, the number of changes, NUM and ADJ, decreased as the dB level increased while the percentage figures in columns N1 and N1-1 evidenced a movement away from the first elapsed time bin. Both of these characteristics imply that the average time between signal level changes at the various dB settings increases as the number of dB increase. To be specific, by taking the data from Fig. 30 it could be calculated that the average time elapsed between 4 and 6 dB fluctuations for the three signal types were:

| Signal Type | 4 dB     | 6 dB     |
|-------------|----------|----------|
| ON          | .195 sec | .362 sec |
| ON/OFF      | .083 sec | .132 sec |
| OFF         | .110 sec | .229 sec |



| SET | BIN | NDB | MEAN  | ALPHA | CHISQ | DF | VARIANCE |
|-----|-----|-----|-------|-------|-------|----|----------|
| 3   | 136 | 4   | 0.116 | -     | -     | -  | -        |
| 3   | 136 | 6   | 0.226 | -     | -     | -  | -        |
| 3   | 154 | 4   | 0.067 | -     | -     | -  | -        |
| 3   | 154 | 6   | 0.108 | 0.93  | 1.43  | 1  | 0.012    |
| 3   | 169 | 4   | 0.088 | 0.87  | 0.004 | 1  | 0.009    |
| 3   | 169 | 6   | 0.179 | 0.34  | 9.18  | 5  | 0.094    |
| 7   | 8   | 4   | 0.102 | -     | -     | -  | -        |
| 7   | 8   | 6   | 0.279 | 0.18  | 5.88  | 5  | 0.432    |
| 7   | 81  | 4   | 0.072 | -     | -     | -  | -        |
| 7   | 81  | 6   | 0.106 | -     | -     | -  | -        |
| 7   | 91  | 4   | 0.229 | 0.34  | 3.26  | 5  | 0.154    |
| 7   | 91  | 6   | 0.985 | 0.18  | 2.73  | 5  | 5.390    |
| 20  | 265 | 4   | 0.096 | -     | -     | -  | -        |
| 20  | 265 | 6   | 0.171 | 0.16  | 8.35  | 5  | 0.183    |
| 20  | 238 | 4   | 0.067 | -     | -     | -  | -        |
| 20  | 238 | 6   | 0.095 | -     | -     | -  | -        |
| 20  | 259 | 4   | 0.090 | 0.94  | 0.34  | 1  | 0.009    |
| 20  | 259 | 6   | 0.189 | 0.50  | 4.00  | 5  | 0.071    |
| 21  | 150 | 4   | 0.100 | -     | -     | -  | -        |
| 21  | 150 | 6   | 0.157 | 0.045 | 7.36  | 5  | 0.548    |
| 21  | 273 | 4   | 0.091 | 0.85  | 1.52  | 1  | 0.010    |
| 21  | 273 | 6   | 0.153 | 0.49  | 4.21  | 5  | 0.048    |
| 21  | 187 | 4   | 0.087 | -     | -     | -  | -        |
| 21  | 187 | 6   | 0.143 | 0.44  | 2.33  | 5  | 0.046    |
| 53  | 19  | 4   | 0.436 | -     | -     | -  | -        |
| 53  | 19  | 6   | 0.748 | -     | -     | -  | -        |
| 53  | 8   | 4   | 0.095 | -     | -     | -  | -        |
| 53  | 8   | 6   | 0.136 | 0.065 | 12.70 | 5  | 0.284    |
| 53  | 50  | 4   | 0.085 | 1.05  | 0.18  | 1  | 0.007    |
| 53  | 50  | 6   | 0.174 | 0.28  | 9.32  | 5  | 0.108    |
| 80  | 82  | 4   | 0.162 | 0.18  | 10.65 | 5  | 0.146    |
| 80  | 82  | 6   | 0.411 | -     | -     | -  | -        |
| 80  | 60  | 4   | 0.101 | -     | -     | -  | -        |
| 80  | 60  | 6   | 0.218 | 0.18  | 14.58 | 5  | 0.264    |
| 80  | 73  | 4   | 0.081 | 1.05  | 0.60  | 1  | 0.006    |
| 80  | 73  | 6   | 0.166 | -     | -     | -  | -        |
| 81  | 4   | 4   | 0.074 | -     | -     | -  | -        |
| 81  | 4   | 6   | 0.106 | -     | -     | -  | -        |
| 81  | 72  | 4   | 0.062 | -     | -     | -  | -        |
| 81  | 72  | 6   | 0.087 | -     | -     | -  | -        |
| 81  | 11  | 4   | 0.069 | -     | -     | -  | -        |
| 81  | 11  | 6   | 0.113 | 0.76  | 2.70  | 5  | 0.017    |
| 126 | 57  | 4   | 0.424 | 0.72  | 1.16  | 5  | 0.250    |
| 126 | 57  | 6   | 0.795 | 0.62  | 8.50  | 5  | 1.019    |
| 126 | 74  | 4   | 0.111 | -     | -     | -  | -        |
| 126 | 74  | 6   | 0.245 | 0.28  | 10.38 | 5  | 0.214    |
| 126 | 8   | 4   | 0.152 | -     | -     | -  | -        |
| 126 | 8   | 6   | 0.452 | 0.51  | 2.68  | 5  | 0.400    |

KEY: NDB = MIN/MAX AMPLITUDE CHANGE VARIABLE  
ALPHA = VALUE OF ALPHA AT MIN CHI SQUARED  
CHISQ = MINIMUM CHI-SQUARED VALUE  
DF = DEGREE OF FREEDOM FOR CHISQ

Figure 30 - CURVE-FITTING DATA

This data confirms that the "ON/OFF" signals fluctuated more rapidly than the other two categories while the "ON" signals proved to be more stable than the "OFF".

These results imply that, if the agency that operates the swept-tuned receiving system used to acquire and record the BRIGHAM data desires to acquire FSK-type signals (roughly, the "ON" variety), it could get away with changing the sensitivity adjustments much less frequently than if Morse-type signals (roughly, the "ON/OFF" variety) were desired. This, plus the rough data provided in Fig. 28, could provide a good data base from which a dial controlling algorithm could be adjusted to meet the needs of the signal types of interest at any time.

As was mentioned above, MIN/MAX 2 provided for the calculation of the mean and standard deviation of the elapsed times tabulated for each of forty-eight signals (the twenty-four signals of interest at both 4 and 6 dB comparison levels). Although the mean values were accurate the standard deviation values were not since the formula used in their calculation is valid for only normal (or Gaussian) distributions. Since the elapsed time histograms were apparently exponential in nature, another form of variance determination was required. This effort called for a curve-fitting technique to identify the histograms as being of a particular distribution type, use of the chi-squared test for goodness-of-fit and manipulation of the chosen distribution's mean and variance formulas to derive the information desired. Attempts were made to fit three distribution functions to the histograms (Gamma, Poisson and Geometric) with the Gamma function proving to be the most successful. The Gamma distribution function, with parameters  $\alpha, \beta$ ,  $0 < \alpha < \infty$ ,  $0 < \beta < \infty$  is defined as follows:

$$f(x) = \begin{cases} (\Gamma(\alpha)\beta^\alpha)^{-1} x^{\alpha-1} e^{-x/\beta}, & x > 0 \\ 0, & x < 0 \end{cases}$$

Where, Mean =  $\alpha\beta$ , Variance =  $\alpha\beta^2$ .

An algorithm was written which read in the observed histogram frequencies, calculated the expected Gamma frequencies (using an International Mathematical Subroutine Library subroutine called MDGAM) and calculated the chi-squared value (essentially, the sum of the least squared differences between the observed and expected frequencies) for use in the goodness-of-fit test. The chi-squared value was then compared with the appropriate value found in the chi-squared distribution table (appropriate as to degrees of freedom and significance level); if it fell below that table entry, the fit was considered good, if not the fit was bad. As discussed in Refs. 7 and 8, a good rule of thumb is that the smaller the chi-squared value for a given number of degrees of freedom, the better the fit. As a word of caution, even an excellent fit (extremely small chi-squared value) does not guarantee that the distribution is really the one being tested, it merely states that the data do not present sufficient evidence to contradict the hypothesis that the histograms possess Gamma distributions.

For the curve-fitting at hand, knowledge of the mean and an iterative variation in  $\alpha$  permitted an iterative calculation of  $\beta$  thus providing all of the necessary information for the algorithm discussed above. The process was refined until the smallest chi-squared value could be identified. It should be noted that only the N1 through N15 time bins were used since very few elapsed times ever fell

beyond five seconds and that, as the individual histogram composition dictated, either seven or three bins were actually used in the algorithm (following a suggestion that bins containing five or fewer counts be combined to enhance the accuracy of the test). The bin limits implied that the degrees of freedom used were five or one respectively.

Of the forty-eight histograms to be fitted, six had counts in too few bins to be useful (would have implied zero degrees of freedom - not found in the table), eighteen were bad fits and the remaining twenty-four provided good fits to the Gamma distribution. Figure 30 gives the results of the curve-fitting effort. Knowledge of  $\alpha$  and the mean implies knowledge of  $\beta$  which, in turn, implies (by definition) knowledge of the variance. A combination of the mean and variance values should be useful in the determination of how often the sensitivity dials on the receiving system should be adjusted for the desired signals to be acquired.

Figure 31 provides a breakdown of the  $\alpha$  values vs. signal type and amplitude change variable for the twenty-four histograms which "fit" the Gamma distribution. It was felt that this would permit the grouping of histograms with respect to some combination of the three categories above. The six ranges shown in the figure imply that any grouping by  $\alpha$  alone would be tenuous indeed as they overlap quite heavily. The only discernable trend is the apparent lowering of the average  $\alpha$  figure as the amplitude change variable increases from 4 to 6 dB. This would seem to contradict the defining equations for the Gamma distribution which imply that a lower  $\alpha$  implies a more "damped-exponential" form for the distribution (when, in fact, the more damped case is found at the 4 dB change variable). However, the shape of the distribution is also a function of  $\beta$  which, as defined in  $\text{Mean} = \alpha\beta$ , tends to affect the distribution shape in a more radical fashion

4 DB

| "CN"             |       | "ON/OFF"    |       | "CFF"            |       |
|------------------|-------|-------------|-------|------------------|-------|
| SET/BIN          | ALPHA | SET/BIN     | ALPHA | SET/BIN          | ALPHA |
| 80/82            | 0.18  | 21/273      | 0.85  | 3/169            | 0.87  |
| 126/57           | 0.72  |             |       | 7/91             | 0.34  |
|                  |       |             |       | 20/259           | 0.94  |
|                  |       |             |       | 53/50            | 1.05  |
|                  |       |             |       | 80/73            | 1.05  |
| RANGE: 0.18-0.72 |       | RANGE: NONE |       | RANGE: 0.34-1.05 |       |
| MEAN: 0.45       |       | MEAN: 0.85  |       | MEAN: 0.85       |       |

6 DB

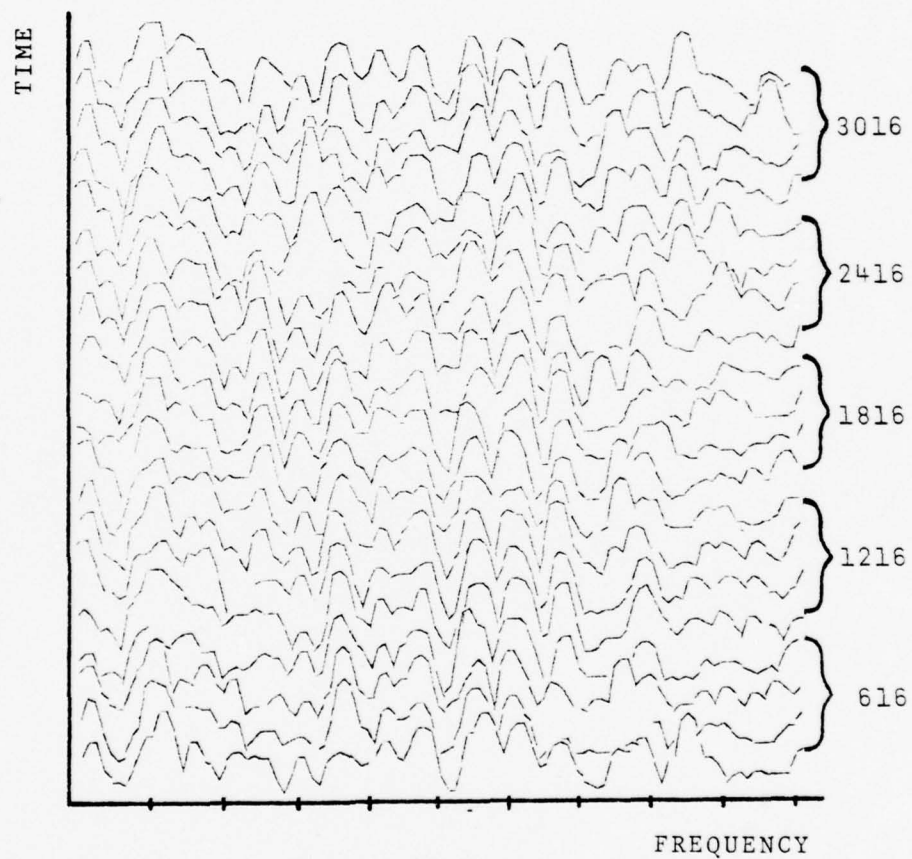
| "CN"              |       | "ON/OFF"          |       | "OFF"            |       |
|-------------------|-------|-------------------|-------|------------------|-------|
| SET/BIN           | ALPHA | SET/BIN           | ALPHA | SET/BIN          | ALPHA |
| 7/8               | 0.18  | 3/154             | 0.93  | 3/169            | 0.34  |
| 20/265            | 0.16  | 21/273            | 0.49  | 7/91             | 0.18  |
| 21/150            | 0.045 | 53/8              | 0.065 | 20/259           | 0.50  |
| 126/57            | 0.62  | 80/60             | 0.18  | 21/187           | 0.44  |
|                   |       | 126/74            | 0.28  | 53/50            | 0.28  |
|                   |       |                   |       | 81/11            | 0.76  |
|                   |       |                   |       | 126/8            | 0.51  |
| RANGE: 0.045-0.62 |       | RANGE: 0.065-0.93 |       | RANGE: 0.18-0.76 |       |
| MEAN: 0.25        |       | MEAN: 0.39        |       | MEAN: 0.43       |       |

Figure 31 - SIGNAL TYPE VS. ALPHA TABLE



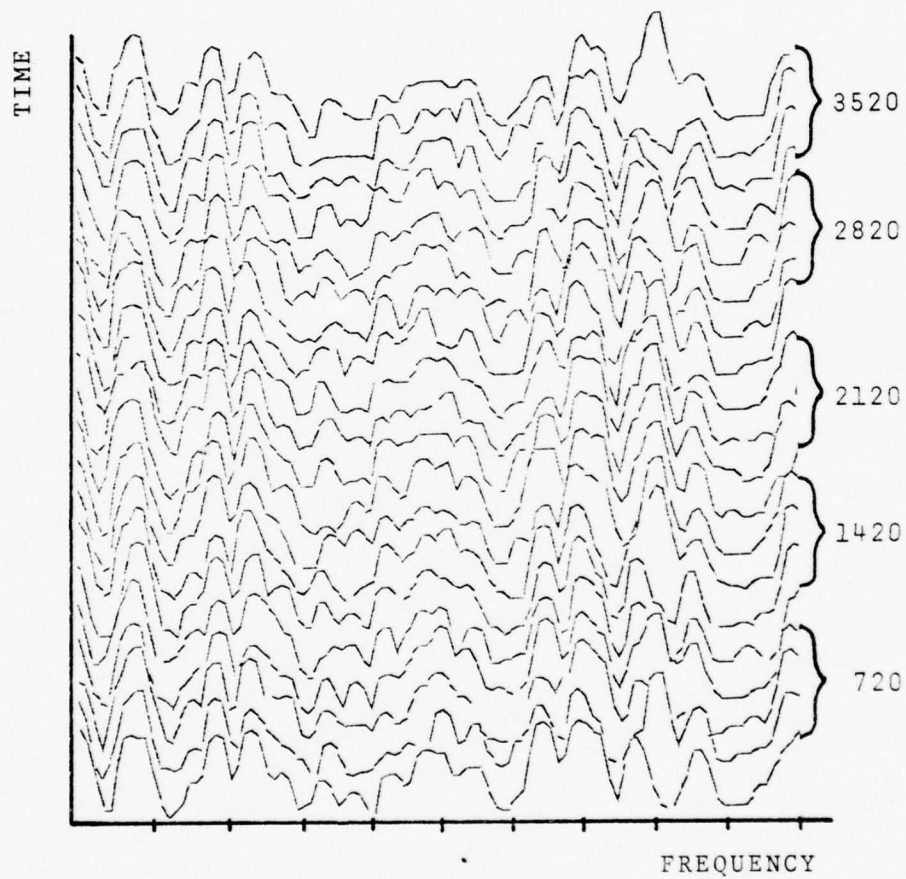
than does  $\alpha$ . In fact, as the change variable increases, the mean increases (see Fig. 30) and  $\alpha$  seems to decrease (see Fig. 31) implying a very pronounced increase in  $\beta$  which, in the defining equations, is found to be most prominent in the exponential term; but, this implies a distribution shape less heavily damped in the lower (4 dB) change variable level. This trend of decreasing values, then, was to be expected and appears to be the only meaningful product of the analysis of the Fig. 31 data.

As an aside on the subject of signal continuity during the brief recorded time span of the waveforms (around 2.4 minutes), it should be noted that data set number 7 bins 81 ("ON/OFF") and 91 ("OFF") exhibited very unusual characteristics when compared with the other signals in their classes. As shown on Fig. 27, bin 81 still had over 1000 changes at 13 dB difference while the other "ON/OFF" signals had fallen off to much smaller numbers. In fact, that bin had two changes at 54 dB when ever-increasing numbers were applied. The "OFF" signal, bin 91, evidenced a similar degree of consistency as it had many fewer 4 dB changes than the other "OFF" signals while falling off much more quickly as the number of decibels increased (see Fig. 28). In fact, this signal had only a few more than 1700 2 dB changes implying exceptional amplitude continuity when compared with any of the twenty-three other signals analyzed. To give a more graphic representation of this phenomenon, Figs. 32 and 33 compare the long-term signal changes found in data sets 3 and 7 with the latter proving to be the more consistent of the two, although even set 3 has a good measure of uniformity throughout its 3600 scans. The base scans for each of the five scan sets (which show the beginning, middle and end of each data set - time-wise) are provided at the right of the pictures.



Base Freq 3.2 MHz, Base Bin 100

Figure 32 - LONG-TERM SIGNAL CONTINUITY - SET 3



Base Freq 11 MHz, Base Bin 1

Figure 33 - LONG-TERM SIGNAL CONTINUITY - SET 7

## V. COMMENTS AND RECOMMENDATIONS

Of the two signal anomaly identification techniques, Anomaly A proved to be the most fruitful. Narrow and wide wavefront discontinuities, fading, frequency shifting of entire wavefronts, frequency shifting of individual signals and several miscellaneous varieties were seen. Two of the above (discontinuities and shifting) were reported on in Ref. 1 with the rest being unique to this study. Several examples of pseudo-anomalies were included to perform the dual function of warning against the false assumption of anomalous performance simply because the plot seemed to imply it and to provide pictures with the narrative in such cases. Analysis with Anomaly B proved to be relatively unproductive as only the interesting and frequently seen phenomenon of signal amplitude undulation (reported in Ref. 1 and expanded upon here) being noted. The diverse and amazingly complex nature of the ionosphere and its interaction with its environment precludes the precise assignment of a cause to every effect (i.e., anomaly). Suffice it to say that, except for those anomalies which can be explained away by equipment malfunction, nothing has been found in this effort which will simplify the model of the ionosphere as an ever-changing medium in which literally anything can happen to a radio signal which traverses it.

The statistical analysis work performed, from creation of the MIN/MAX algorithms to the tedious curve-fitting effort, resulted in a wealth of predominantly raw data which, with the mean and variance values, should provide a foundation upon which a receiver system sensitivity dial-controlling algorithm could be refined. It was noted

in the curve-fitting section that it is perhaps the weakest link in the statistical study since the chi-squared test guarantees neither that the elapsed time histograms are Gamma distributions nor that there might exist other distributions which would "fit" the histogram data as well as the Gamma function did. However, a statistically reasonable argument can be made that the histograms (at least half of them) are probably Gamma in nature and, hence, the variance values calculated can be accepted as accurate.

Should additional work be done with the BRIGHAM data, the following remarks/recommendations could prove useful:

(1) all of the complete data sets in hand have been thoroughly analyzed with program Anomaly A - additional effort along this line might be a waste of time and energy;

(2) although nearly twenty of the data sets in hand have not been analyzed with program Anomaly B, the disappointing results thusfar might act as a warning as to expected future rewards from additional effort;

(3) if Anomaly A and/or Anomaly B are to be used again, the BAKSCN feature found in the METASYMBOL subroutine (it provides for the backing over of a specified number of files, or data sets) should be made to work as a time/labor saving device - the problem is in the magnetic tape unit, not the program;

(4) the recommendation (made initially in Ref. 1) for the creation of a computer algorithm to search out the anomalies in an automatic and, hence, more rapid manner than the visual approach is guardedly endorsed herein - although the speed at which the data sets could be analyzed would be improved by at least an order of magnitude, the extreme complexity of trying to tell the computer what to look for



as well as the loss of that very intangible but valuable human discretionary power could combine to make this effort a quagmire;

(5) should additional work be done utilizing the MIN/MAX routines, Anomaly B should be used first to enhance the accuracy in selecting the different signal types to be analyzed - that this was not done in the present study may have resulted in the rather large ranges found in the data;

(6) the accuracy of any future curve-fitting work could be enhanced by the inclusion of the Weibull and Lognormal distributions (or any of the level-crossing distributions) to the list of possible curves to which the elapsed time histograms are matched because sets of such data can be fitted to more than one distribution with equal accuracy and validity - this was not done here because the suggested distributions were complex enough and the time remaining short enough that a good effort could not have been put forth.

## GLOSSARY

1. Sporadic-E: thin horizontal layer (or patches) of high electron density embedded in the regular E layer resulting in signal deflection and/or absorption.
2. Night-Day Asymmetry: less attenuation at night than day due to difference in the ionizing effect of the sun resulting in discontinuities during the sunrise/sunset periods.
3. Geomagnetic Non-Reciprocity: different attenuation effects on signals travelling west to east rather than east to west due to the earth's magnetic field lines.
4. Polar Cap Absorption (PCA): absorption of radio signals passing the polar regions - due to a combination of solar flare activity and the shape of the earth's magnetic field lines.
5. Auroral Display: brightly colored northern latitude phenomena disruptive to communications - also as the result of a combination of solar flare activity and the earth's magnetic field lines.
6. Faraday Rotation: any linearly polarized wave travelling in the direction of a magnetic field results in its two circularly polarized components travelling at different velocities and thus the plane of polarization will rotate with distance.

7. Ducting: if a radio wave comes into contact with a region of inhomogeneous refractive indices the wave could be trapped between two layers and guided, as in a leaky wave guide, away from its intended destination.
8. Fading (Dellinger Effect): sudden ionospheric disturbance (S. I. D.) which produces a complete radio "fade out" lasting from a few minutes to an hour or more - caused by solar flare activity.

#### LIST OF REFERENCES

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4. Gerson, N. C., Editor, Radio Absorption in the Ionosphere, p. 1 to 29, 106 to 317, Pergamon Press, 1962.
5. Jordan, E. C. and Balmain, K. G., Electromagnetic Waves and Radiating Systems, p. 667 to 699, Prentice-Hall, Inc., 1968.
6. Ratcliffe, J. A., An Introduction to the Ionosphere and Magnetosphere, p. 1 to 131, University Press, 1972.
7. Breiman, L., Statistics: With a View Towards Applications, p. 176 to 217, Houghton Mifflin Co., 1973.
8. Freund, J. E., Modern Elementary Statistics, p. 272 to 293, Prentice-Hall, Inc., 1965.

```

C C PROGRAM TO READ ONE DATA SET (APPROX 7200 CARDS) ONTO A 5-TRACK TAPE
C C - IN THIS CASE, THE DATA SET WILL OCCUPY LABEL (CR REGION) CNE CN
C C TAPE NPS611 WITH TAPE DENSITY 800 BPI AND EVEN PARITY.
C C
C C // EXEC FCRTCLG
C C //FCRT.SYSIN DD *
C C LCGICAL*1 INFO(160)
C C 5 READ(4,1,END=99) INFO
C C 1 FCORMAT(160A1)
C C WRITE(2,1) INFO
C C GC TO 5
C C 99 ENCFILE 2
C C STOP
C C END
C C //GC.FTC2F001 DD UNIT=3400-4, VOL=SER=NPS611,
C C // LABEL=(1,SL), DSN=FILE1, DISP=(NEW,KEEP),
C C // DCB=(RECFM=FB, LRECL=160, BLKSIZE=320, CEN=2)
C C //GC.FTC4F001 DD UNIT=2540, DCB=(MODE=C, BLKSIZE=160)

```



```

PROGRAM TO TRANSFER DATA FROM A 9-TRACK TAPE TO A 7-TRACK TAPE - IN
THIS CASE, DATA SETS 1 THROUGH 4 FROM 9-TRACK TAPE NPSC11 WILL
OCCUPY LABELS 1 THROUGH 4 ON 7-TRACK TAPE R0WEC8 WITH TAPE DENSITY
556 EPI AND CDD PARITY.

      EXEC PGM=IEBGENER
      //SYSPRINT DD SYSOUT=A
      //SYSUT1 DD UNIT=3400-4,DISP=(OLD,KEEP),LABEL=(1,SL),
      //VCL=SER=NPSC11,DSN=FILE1
      //SYSUT2 DD UNIT=2400-1,DISP=(NEW,KEEP),LABEL=(1,NL),
      //VCL=SER=RCWE08,DCB=(RECFM=FB,LRECL=160,BLKSIZE=320,DEN=1)
      //SYSIN DD DUMMY
      //TAC EXEC PGM=IEBGENER
      //SYSPRINT DD SYSOUT=A
      //SYSUT1 DD UNIT=3400-4,VOL=(,RETAIN,REF=*,ONE.SYSUT1),
      //DISP=(CLD,PASS),DSNAME=FILE1,LABEL=(2,SL)
      //SYSUT2 DD UNIT=2400-1,VCL=(,RETAIN,REF=*,ONE.SYSUT2),
      //DISP=(NEW,PASS),DCB=*,CNE.SYSUT2,LABEL=(2,NL)
      //SYSIN DD DUMMY
      //TREC EXEC PGM=IEBGENER
      //SYSPRINT DD SYSOUT=A
      //SYSUT1 DD UNIT=3400-4,VOL=(,RETAIN,REF=*,ONE.SYSUT1),
      //DISP=(CLD,PASS),DSNAME=FILE1,LABEL=(2,SL)
      //SYSUT2 DD UNIT=2400-1,VCL=(,RETAIN,REF=*,CNE.SYSUT2),
      //DISP=(NEW,PASS),DCB=*,ONE.SYSUT2,LABEL=(3,NL)
      //SYSIN DD DUMMY
      //FLR EXEC PGM=IEBGENER
      //SYSPRINT DD SYSOUT=A
      //SYSUT1 DD UNIT=3400-4,VCL=(,RETAIN,REF=*,ONE.SYSUT1),
      //DISP=(CLD,PASS),DSNAME=FILE1,LABEL=(4,SL)
      //SYSUT2 DD UNIT=2400-1,VCL=(,RETAIN,REF=*,ONE.SYSUT2),
      //DISP=(NEW,PASS),DCB=*,CNE.SYSUT2,LABEL=(4,NL)
      //SYSIN DD DUMMY

```

```

CC CC PROGRAM TO PRINT OUT RECORDS FROM A 9-TRACK TAPE - IN THIS CASE,
CC CC THE FIRST RECORDS FROM LABEL 1 OF TAPE NPS611 WILL BE DUMPED TO
CC CC PERMIT VERIFICATION OF DATA TRANSFER.
CC CC
CC CC // EXEC TAPEOUT,PARM='0,4,,1,320'
CC CC //TAPEIN DD UNIT=3400-4,VOL=SER=NPS611,LABEL=(2,BLP)

```

```

CC CC PROGRAM TO PRINT OUT RECCRDS FROM A 7-TRACK TAPE - IN THIS CASE,
CC CC THE FIRST FOUR RECORDS FROM LABEL 1 OF TAPE ROWE1 WILL BE DUMPED
CC CC TO PERMIT VERIFICATION OF DATA TRANSFER.
CC CC
CC CC // EXEC TAPEOUT,PARM='0,4,,1,320'
CC CC //TAPEIN DD UNIT=2400-1,VCL=SER=ROWE1,LABEL=(1,ELF)

```





```

* * * * *
SAMPLE FUNCTION SWITCHES
JSW(3) = NAMELIST INPUT
JSW(4) = LOOP (HOLDS NEXT PICTURE)
JSW(5) = LOOP BREAKER (ADVANCE AUTOMATICALLY)
JSW(6) = WRITES AXIS AND SCAN DATA ON KTAPE FM CURRENT PICTURE
JSW(7) = WRITES END OF FILE (ECF) ON DATA OUTPUT TAPE (#2)
JSW(8) = REWINDS DATA TAPE

CALL FNS(IDEV, ISW, IER)
IF(IER.NE.0)OUTPUT(101)IER, 'FNS ERR'
JW=LXCR(JW, ISW)

* * *
FCL ROUTINE(TO 11) WRITES JSW NRS(3 OR 4) ON SCREEN WHEN ACTIVE

LE=1
CC 10 I=3,4
IF(JSW(1).EQ.0)GO TC 10
FNCCE(4,9,ITXT)I
FCFMAT(11)
CALL TEXTTO(IDEV, ITXT, 1, LB, 1, 1, 2, IER)
IF(IER.NE.0)OUTPUT(101)IER, JSW
LE=LB+1
CCNTINUE
CC 11 I=LB,2
CALL TEXTTO(IDEV, NULL, 1, 1, 1, 1, 3, IER)
IF(IER.NE.0)OUTPUT(101)IER, JSW NULL
IF(JSW(3).EQ.0)GO TC 12
IELK=4
CALL GINP(IDEV, ITCR, IBLK)

* * *
GINFL WITH GINP ALLOWS NAMELIST INPUT AT ACT

JW=JCFF(3)
IF(JSW(4).EQ.0)GO TC 17
CALL FNS(IDEV, ISW, IER)
IF(IER.NE.0)OUTPUT(101)IER, 'FNS1 ERR'
JW=LXCR(JW, ISW)
IF(JSW(5).NE.0)JW=JCFF(4);JW=JCFF(5);GO TC 17
IF(JSW(6).NE.0)GO TC 95
CC TC 12
IF(JSW(7).NE.0)ENDFILE KTAPE;JW=JCFF(7)
IF(JSW(8).NE.0)REWIND 1;JW=JCFF(8)

* * * * *
SAMPLE CONTROL DIALS

DIAL(1) = ANGLE OF Z AXIS
DIAL(2) = CURSOR POSITION

```



```

30 IF(ICIAL.NE.1)GO TO 35
   CALL VCD(1,DIALS,IER)
   IF(IER.NE.0)OUTPUT(101)IER,'DIALS'
*
* EVALUATE DISPLAY PARAMETERS
*
35 CCNTINUE
   IF(IDELAY.EQ.0)GO TO 36
   IA=IDELAY*100000
   CALL DELAY
   ISTCP=ISTRT+IWDTH-1
   WIDTH=IWDTH
   ALFA=NMBR JMP+1
   IF(IERANCEP.EQ.1)GO TO 40
   CX=2.4/WIDTH
   IANGL=9C*DIALS(1)
   ANGL=IANGL*PI/180
   Z=INSCAN-1)*SEP
   ZY=Z*SIN(ANGL)
   ZY=Z*CCS(ANGL)
   XSLNT=SEP*SIN(ANGL)
   YSLNT=SEP*COS(ANGL)
*
* FORMAT AND PACK AXIS DATA INTO AXES ARRAY
*
   AXES(1)=IHEAD(0,5)
*
* Y AXIS
*
   AXES(2)=IPACK(X1,Y1+Z,0)
   AXES(3)=IPACK(X1,Y1,1)
*
* X AXIS
*
   AXES(4)=IPACK(X1+2.45,Y1,1)
   AXES(5)=IPACK(X1,Y1,0)
*
* Z AXIS
*
   AXES(6)=IPACK((X1+ZX),(Y1+ZY),1)
*
* X AXIS SCALE MARKS
*
CC 45 I=2,26,2
   II=I+5
   IF(I*5.GT.IWDTH)AXES(II)=AXES(II+1)=0;GO TO 45
   AXES(II)=IPACK(X1+I*5*CX,Y1-.03,0)
   AXES(II+1)=IPACK(X1+I*5*DX,Y1+.02,1)
   CCNTINUE
45

```

```

* * *
* Y AXIS SCALE MARKS
*
46  CC 46 I=2,12,2
*    I1=I+31
*    AXES(I1)=IPACK(X1+.02,Y1+(2.5/SCALE)*I,0)
*    AXES(I1+1)=IPACK(X1+.01,Y1+(2.5/SCALE)*I,1)
*    CC CONTINUE
*
* CLRSR
*
* AXES(47)=C
50  CC 50 I=1,NSCAN
*    MCV(I,1)=0
*
* BRING IN NEW SCANS, MOVE OFF OLD SCANS
*
60  CC 60 I=NSCAN,NALFA,-1
*    CC 60 J=1,IWDTH
*    MCV(I,J)=MCV(I-NMBRJMP,J)
*    FILE(J,I)=FILE(J,(I-NMBRJMP))
*    IF(NSCAN.GE.MSCAN)GC TC 65
*
* ZERO OUT THAT PORTION OF *FILE* ACT BEING USED
*
61  CC 61 I=NSCAN+1,MSCAN
*    CC 61 J=ISTRT,ISTOP
*    FILE(J,I)=0
*
* READ DATA FROM TAPE
*
65  CC 72 N=1,NMBRJMP
*    IF(NSKIP.EQ.0)GO TC 67
*    CC 66 J=1,NSKIP
*    CALL BUFFERIN(1,TAPE,1,IBUF,80,IND)
67  CC 67 IF(IND.EQ.1) GO TC 20
*    NR=NR+1
*    GC TC (20,66,90,66),IND
66  CC CONTINUE
*    CC 29 K=0,1
*    N=N+160
*    CC 25 I=1,40
*    CC 25 J=1,4
*    IF FILE(M+J+1)=LRS(LAND(IBUF(K*40+1),MASK(J)),ISHT(J))
22  N=N+4
25  CC CONTINUE
*    IF FILE(1)=NR
71  CC 72 I=ISTRT,ISTOP

```

```

* * *
* * * 72
* * * FILE((I-ISTRT+1),(NALFA-N))=IFILE(I+1)/SCALE
* * * NRSCAN=SCAN NR TO BE DISPLAYED ON SCREEN
* * *
* * * 50
* * * NRSCAN=IFILE(1)
* * * CALL REMOVAL(NSCAN,IWDTH)
* * * CALL DISPLAY(NSCAN,IWDTH)
* * * GC TC 8
* * * CPUTUT(101),'END CF DATA TAPE'
* * *
* * * NR=C
* * * GC TO 75
* * *
* * * PACKS GRAPHICS DATA INTO PROPER FORMAT FOR OUTPUT DATA TAPE..
* * *
* * * 55 CALL HEADER (KTAPE,IWDTH,IWDTH,NSCAN)
* * * CALL GRAPHI(IDEV,IMAGE,2,IER)
* * * IF(IER.NE.0)OUTPUT(101),'GIER'
* * * GC 58 I=1,NSCAN
* * * GC 57 J=1,IWDTH
* * * INCX=(I-1)*IWDTH+J
* * * CALL UNPACK(IMAGE(INDX),PBUF(1,J),PBUF(2,J),MC)
* * * 57 PBUF(2,J)=LIGR(LAND(PBUF(2,J),77777768),MC)
* * * CALL BUFFEROU(KTAPE,1,PBUF,2*IWDTH,IND)
* * * 56 IF(INC.EQ.1) GO TC 96
* * * 58 CONTINUE
* * * JW=JCHF(6)
* * * GC TC 13
* * * END

```

```

SUBROUTINE REMOVAL(NSCAN,IWIDTH)
  INTEGER AXES(47)
  COMMON /AREA1/FILE(130,20),MCV(20,130),IMAGE(2000)
  COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,DX,AXES,NBRJMP,NRSCAN

  * THIS SUBROUTINE ERASES LINE SEGMENTS HIDDEN BEHIND OTHER LINES
  *
  LAST=0
  NR=NSCAN
  DO 110 J=1,NR
  DO 110 J=2,IWIDTH
    MCV(I,J)=1
    DO 140 K=NR,2,-1
    DO 140 L=K-1,K-4,-1
    IF(L.LT.1)GO TO 140
    LI=K-L
    HEIGHT=LL*YSLNT
    DO 140 J=1,IWIDTH
    IF(MCV(K,J)).EQ.0)GC TC 140
    INDX=J+LL*(XSLNT/DX+0.4)
    IF(INDX.GT.IWIDTH)GC TO 140
    TEST=FILE(J,K)+HEIGHT
    REF=FILE(INDX,L)
    IF(REF.LT.TEST)GO TC 138
    MCV(K,J)=LAST=0
    IF(REF-TEST.LT.FILE(J-1,K)-FILE(INDX-1,L))MCV(K,J)=1;GC TO 135
    GC TO 140
  IF(LAST.NE.0)GO TC 140
  IF(FILE(J,K)-FILE(J-1,K).GT.TEST-REF)MOV(K,J)=LAST=C;GO TO 140
  LAST=1
  CCCONTINUE
  RETURN
  END

```

```

SUBROUTINE DISPLAY(NSCAN,IWDTH)
  INTEGER AXES(47)
  COMMON /AREAL/FILE(130,20),MCV(20,130),IMAGE(2000)
  COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,DX,AXES,NBRJMP,NRSCAN

  * THIS SUBROUTINE PACKS DATA INTO PROPER FORMAT FOR GRAPHICS UNIT
  *
  *
  200 N=1
      IMAGE(1)=IHEAD(0,10)
      CC 210 I=1,NSCAN
      X=X1+XSLNT*(I-1)
      Y=Y1+YSLNT*(I-1)
      CC 210 J=1,IWDTH
      N=N+1
      M=NCV(I,J)
      EX=X+DX*(J-1)
      WYE=Y+FILE(J,I)
      IF(EX.GT.1.3)M=0
      IMAGE(N)=IPACK(EX,WYE,M)
      CC 211 I=N+1,2000
      IMAGE(I)=0
      CALL GRAPH-C(IDEV,AXES,47,1,IER)
      IF(IER.NE.0)OUTPUT(101),IER,AXES,ERR
      CALL GRAPH-C(IDEV,IMAGE,2000,2,IER)
      IF(IER.NE.0)OUTPUT(101),IMAGER,ERR
      ENCCODE(4,220,JXT)NRSCAN
      FCFMAT(14)
      CALL TEXTIO(IDEV,JXT,1,40,75,2,2,IER)
      IF(IER.NE.0)OUTPUT(101),IER,NRSCAN,ERR
      RETURN
  END
  210
  211
  220

```



```

SUBROUTINE HEADER (KTAPE,IWDTH,NSCAN)
  INTEGER PBUF
  DIMENSION PBUF(2,130),I+BUF(260)
  EQUIVALENCE(PBUF,IHBUF)

```

```

* THIS SUBROUTINE PACKS THE DATA FOR PROPER PLCT FORMAT FOR USE ON THE
* PDF-11 PLCTTER.

```

```

  DO 10 I=1,2
    DO 10 J=1,IWDTH
      PELF(I,J)=0
      I+BUF(1)=IWDTH
      I+BUF(2)=NSCAN
      CALL BUFEFCU(KTAPE,1,I+BUF,2*IWDTH,IND)
      IF(IND.EQ.1) GO TO 20
    RETURN
  END

```

```

* * * * *
ANCMALY B - PROGRAM TO DRAW A SERIES OF FIVE SCANS (ANCMALY A STYLE)
AND FIVE PRESELECTED BINS PRESENTED AS TIME VS. AMPLITUDE TRACES
DIRECTLY ABOVE.

REQUIRES SENSE SW. 2 AND FOL CONTROL CARDS (LEFT JUSTIFIED TO COL 1)

$PATCH
$>>DATA
CC7067 00106711
$ENC
-AGT
-JCB ANCMALY B
-FOR TRAN LS,GO
MSK(1)=LAND(ISW,LLS(1,23-1))
JSH(1)=LAND(JW,LLS(1,23-1))
JCN(1)=LIOR(JW,LLS(1,23-1))
JCFF(1)=LAND(JW,LXCR(-1,LLS(1,23-1)))
INTEGER PBUF
INTEGER AXES(113)
DIMENSION DIALS(6),IFILE(321),AVECTR(405)
DIMENSION ICDIR(4),ITDIR(7)
DIMENSION IBUF(80),MASK(4),ISHT(4)
DIMENSION PBUF(2,130),IHBUFF(260)
EQUIVALENCE(PBUF,IHBUFF)
DATA (MASK(1),I=1,4),(ISHT(1),I=1,4)/370000COB,3700CCB,3700B,1
18,12,6,C/
COMMON /AREA1/FILE(318,5),MOV(5,318),IMAGE(1591),AMPTIST(5,81)
COMMON /AREA2/IDEV,XSLNT,YSLNT,X1,Y1,Y2,CX,AXES,NMBRJMP,NRSCAN
COMMON /AREA3/JMAGE(406),SCALE2,IBIN1,IBIN2,IBIN3,IBIN4,IBIN5
EQUIVALENCE (AMPHIST(1,1),AVECTR(1))
EQUIVALENCE IDEV,IDIAL,SCALE,SEF,NSCAN,IWDTF,ISTRT,X1,Y1,ITAPE,Y2
NAMELIST DIALS,NMBRJMP,NSKIP,IDELAY,DX,IERANCH
NAMELIST IBIN1,IBIN2,IBIN3,IBIN4,IBIN5,SCALE2
NAMELIST NFILE
DATA NFILE/0/

INITIALIZATION OF PARAMETERS

IDEV: AGT NUMBER(1 OR 2)
ICEV=1
ICIAL: DIALS SAMPLED ONLY IF IDIAL=1
IF NOT SAMPLED,MUST SPECIFY VALUE OF DIALS(1)& (2)
ICIAL=1
IERANCH: CALCULATES SCALES DIST BETWEEN FREQ BINS IF IERANCH=0
IERANCH=0 IF IERANCH.NE.0, MUST SPECIFY WIDTH(DX)

```



```

CALL CTINIT(IDEV,ITCIR,7,IER)
IF(IER.NE.0) OUTPUT(101)IER,'DTINIT ERR'
CALL TEXTTO(IDEV,NULL,1,40,75,2,3,IER)
IF(IER.NE.0)OUTPUT(101),'NRSCAN NULL ERR'
MSCAN=NSCAN

SAMPLE FUNCTION SWITCHES
JSW(3) = NAMELIST INPUT
JSW(4) = LOOP (HCLOS NEXT PICTURE)
JSW(5) = LOOP BREAKER (ADVANCE AUTOMATICALLY)
JSW(6) = WRITES AXIS AND SCAN DATA ON KTAPE FM CURRENT PICTURE
JSW(7) = WRITES END OF FILE (ECF) ON DATA OUTPUT TAPE
JSW(8) = REWINDS DATA TAPE
JSW(9) = ZEROES OUT AMPLITUDE HISTORY DISPLAY
CALL FNS(IDEV,ISW,IER)
IF(IER.NE.0)OUTPUT(101)IER,'FNS ERR'
JW=LXOR(JW,ISW)

FCL ROUTINE(TO 11) WRITES JSW NRS(3 OR 4) CN SCREEN WHEN ACTIVE
LE=1
CC 10 I=3,4
IF(JSW(1).EQ.0)GO TC 10
ENCODE(4,9,ITXT)I
FORMAT(11)
CALL TEXTTO(IDEV,ITXT,1,1,1,1,3,IER)
IF(IER.NE.0)OUTPUT(101)IER,'JSW'
LE=LB+1
CONTINUE
CC 11 I=LB,2
CALL TEXTTO(IDEV,NULL,1,1,1,1,3,IER)
IF(IER.NE.0)OUTPUT(101)IER,'JSW NULL'
IF(JSW(2).EQ.0)GO TC 12
IELK=4
CALL GINP(IDEV,ITCIR,IBLK)

GINPUT WITH GINP ALLOWS NAMELIST INPUT AT ACT
JW=JCFF(3)
IF(JSW(4).EQ.0)GO TC 17
CALL FNS(IDEV,ISW,IER)
IF(IER.NE.0)OUTPUT(101)IER,'FNS1 ERR'
JW=LXOR(JW,ISW)
IF(JSW(5).NE.0)JW=JCFF(4);JW=JCFF(5);GO TC 17
IF(JSW(6).NE.0)GO TC 95
GC TC 12
IF(JSW(7).NE.0)ENDFILE KTAPE;JW=JCFF(7)
IF(JSW(8).NE.0)REWIND 1;JW=JCFF(8)

```

8 \* \* \* \* \*

\* \* \*

9

10

11

\* \* \*

12  
13

15

17

```

18 IF (JSW(9).EQ.0)GO TC 30
CC 18 I=1,405
AVECTR(I)=C
JW=JCPF(7)

* * * * *
30 SAMPLE CONTROL DIALS
    CIAL(1) = ANGLE CF Z AXIS
    CIAL(2) = CURSCR POSITION
    IF (ICIAL.NE.1)GO TC 35
    CALL VCC(1,DIALS,IER)
    IF (IER.NE.0)OUTPUT(101)IER,'DIALS'

* * * * *
35 EVALUATE DISPLAY PARAMETERS
CONTINUE
IF (IDELAY.EQ.0)GO TC 36
IA=IDELAY*100000
CALL DELAY
I=ICP=1*STRT+IWDTH-1
WIDTH=IWDTH
NALFA=NMBR*JMP+1
IF (IERANCH.EQ.1)GO TO 40
IX=2.15/WIDTH
IANGL=90*DIALS(1)
ANGL=IANGL*PI/180
Z=(NSCAN-1)*SEP
ZX=Z*SIN(ANGL)
ZY=Z*COS(ANGL)
XSLNT=SEP*SIN(ANGL)
YSLNT=SEP*CCS(ANGL)

* * * * *
FCFMT AND PACK AXIS DATA INTO AXES ARRAY
    AXES(1)=IHEAD(0,4)
Y AXIS
    AXES(2)=IPACK(X1,Y1+Z,0)
    AXES(3)=IPACK(X1,Y1,1)
X AXIS
    AXES(4)=IPACK(X1+2.45,Y1,1)
    AXES(5)=IPACK(X1,Y1,0)
Z AXIS
    AXES(6)=IPACK((X1+ZX),(Y1+ZY),1)
X AXIS SCALE MARKS
CC 45 I=2,64,2
I=1+5
IF (I*5.GT.IWDTH)AXES(11)=AXES(11+1)=0;GO TC 45
AXES(11)=IPACK(X1+I*5*DX,Y1-.03,C)

```





```

65  CC 76,N=1,NMBRJUMP
    IF(NSKIP-EQ.0)GO TC 67
    CC 66 J=1,NSKIP
    67  CALL BUFFERIN(ITAPE,1,IBUF,80,INC)
    20  IF(INC-EQ.1) GO TC 20
    NR=NR+1
    GC TO (20,66,90,66),IND
    66  CC CONTINUE
    N=K*160
    CC 29 K=0,1
    CC 25 I=1,40
    CC 23 J=1,4
    23  IF(ILE(M+J+1))=LRS(LAND(IBUF(K*40+1)),MASK(J)),ISHT(J))
    25  N=M*4
    25  CC CONTINUE
    IF(ILE(1))=NR
    CC 72 I=ISHT,ISHTCP
    FILE((1-ISHT+1),(NALFA-N))=IFILE(I+1)/SCALE
    NRSCAN=SCAN NR TO BE DISPLAYED ON SCREEN
    72  NRSCAN=IFILE(1)
    *
    *
    *
    PICK MAX OF 3 BINS FOR AMPHIST VALLE (CENTER AT IBIN+1)
    NN=NALFA-N
    AMPHIST(1,NN)=AMAX(IFILE(IBIN1),IFILE(IBIN1+1),IFILE(IBIN1+2))/SCALE
    ILE
    AMPHIST(2,NN)=AMAX(IFILE(IBIN2),IFILE(IBIN2+1),IFILE(IBIN2+2))/SCALE
    ILE
    AMPHIST(3,NN)=AMAX(IFILE(IBIN3),IFILE(IBIN3+1),IFILE(IBIN3+2))/SCALE
    ILE
    AMPHIST(4,NN)=AMAX(IFILE(IBIN4),IFILE(IBIN4+1),IFILE(IBIN4+2))/SCALE
    ILE
    AMPHIST(5,NN)=AMAX(IFILE(IBIN5),IFILE(IBIN5+1),IFILE(IBIN5+2))/SCALE
    ILE
    CALL REMOVAL(NSCAN,IWDTH)
    CALL DISPLAY(NSCAN,IWDTH)
    GC TC 8
    50  CLIPUT(101),'END CF DATA TAPE'
    NR=0
    GC TO 12
    *
    *
    *
    CLIPUT DATA FOR PLCTTING GRAPH
    55  CALL FEADER (KTAPE,81,1C)
    CALL GRAPHI(IDEV,JMAGE,3,IER)
    IF(1ER,NE.C)OUTPUT(101),'GIER'
    CC 58 I=1,5
    CC 57 J=1,81

```

```

INCX=(I-1)*81+J
CALL UNPACK(JMAGE(INDX),PBUF(1,J),PBUF(2,J),MC)
PELF(2,J)=LICR(LAND(PBUF(2,J),7777776B),MC)
CALL BUFFEROU(KTAPE,1,PBUF,162,INC)
IF(INC.EQ.1) GO TO 96
CONTINUE
CALL GRAPH1(IDEV,IMAGE,2,IER)
IF(IER.NE.0)OUTPUT(101),GIER,
CC 101 I=1,5
CC 100 J=1,81
INCX=(I-1)*IWDTH+J
CALL UNPACK(JMAGE(INDX),PBUF(1,J),PBUF(2,J),MC)
PELF(2,J)=LICR(LAND(PBUF(2,J),7777776B),MC)
CALL BUFFEROU(KTAPE,1,PBUF,162,INC)
IF(INC.EQ.1) GO TO 59
CONTINUE
J4=JCHF(6)
CC TC 13
END

```

```

SUBROUTINE REMOVAL(NSCAN,IWDTH)
INTEGER AXES(113)
COMMON /AREAL/FILE(318,5),MCV(5,318),IMAGE(1591),AMPFIST(5,81)
COMMON /AREA2/IDEV,XSLNT,X1,Y1,Y2,CX,AXES,NMBRJMP,NRSCAN
COMMON /AREA3/JMAGE(406),SCALE2,IBIN1,IBIN2,IBIN3,IBIN4,IBIN5

* THIS SUBROUTINE ERASES LINE SEGMENTS HIDDEN BEHIND OTHER LINES
*
105 LAST=0
    NR=NSCAN
    CC 110 I=1,NR
    CC 110 J=2,IWDTH
    MCV(I,J)=1
    CC 140 K=NR,2,-1
    CC 140 L=K-1,K-4,-1
    IF(L.LT.1)GO TO 140
    I=K-L
    HEIGHT=LL*YSLNT
    CC 140 J=1,IWDTH
    IF(MCV(K,J)).EQ.0)GO TC 140
    INDX=J+LL*(XSLNT/DX+.4)
    IF(INDX.GT.IWDTH)GO TC 140
    TEST=FILE(J,K)+HEIGHT
    REF=FILE(INDX,L)
    IF(REF.LT.TEST)GO TC 138
    MCV(K,J)=LAST=0
    IF(REF-TEST.LT.FILE(J-1,K)-FILE(INDX-1,L))MCV(K,J)=1;GO TO 139
    CC TC 140
137 IF(LAST.NE.0)GO TC 140
138 IF(FILE(J,K)-FILE(J-1,K).GT.TEST-REF)MOV(K,J)=LAST=C;GO TO 140
139 LAST=1
140 CC CONTINUE
    RETURN
END

```

```

SUBROUTINE DISPLAY(NSCAN, IWETH)
  INTEGER AXES(113)
  COMMON /AREAL/FILE(318,5),MOV(5,318),IMAGE(1591),AMPHIST(5,81)
  COMMON /AREA2/IDEV,XSLNT,X1,Y1,Y2,CX,AXES,AMBRJMP,NRSCAN
  COMMON /AREA3/JMAGE(406),SCALE2,IBIN1,IBIN2,IBIN3,IBIN4,IBIN5
  * THIS SUBROUTINE PACKS DATA INTO PROPER FORMAT FOR GRAPHICS UNIT
  *
  EX=2.3/E0.C
  N=1
  IMAGE(1)=IHEAD(0,10)
  DO 210 I=1,NSCAN
    X=X1+XSLNT*(I-1)
    Y=Y1+YSLNT*(I-1)
    DO 210 J=1,IWDTH
      N=N+1
      N=NCV(I,J)
      EX=X+DX*(J-1)
      WYE=Y+FILE(J,I)
      IF(EX.GT.1.3)M=0
      IMAGE(N)=IPACK(EX,WYE,M)
    DO 211 I=N+1,1591
      IMAGE(I)=0
    N=1
    JMAGE(1)=IHEAD(0,10)
    DO 215 I=1,5
      DO 215 J=1,81
        N=N+1
        EX=X1+BX*(J-1)
        WY=Y2+AMPHIST(I,J)-(30.0/SCALE2)*I
        JMAGE(N)=IPACK(EX,WY,1)
        IF(J.EQ.1)JMAGE(N)=IPACK(EX,WY,0)
        JMAGE(82)=JMAGE(163)=JMAGE(244)=JMAGE(325)=JMAGE(406)=0
        CALL GRAPFC(IDEV,AXES,113,1,IER)
        IF(IER.NE.0)OUTPUT(101),IER,AXES,ERR
        CALL GRAPFC(IDEV,IMAGE,1591,2,IER)
        IF(IER.NE.0)OUTPUT(101),IMAGE,ERR
        CALL GRAPHC(IDEV,JMAGE,406,3,IER)
        IF(IER.NE.0)OUTPUT(101),AMPHIST,ERR
        ENCCODE(4,220,JTXT),NRSCAN
        FCFMAT(14)
        CALL TEXT0(IDEV,JTXT,1,40,75,2,3,IER)
        IF(IER.NE.0)OUTPUT(101),IER,NRSCAN,ERR
        RETURN
      EN
    210
  211
  215
  220

```



```

SLERCUTINE HEADER (KTAPE,IWETH,NSCAN)
INTEGER PBUF
DIMENSION PBUF(2,130),IHBUF(260)
ECLIVALENCE(PBUF,IHBUF)

```

```

* * * * *
THIS SLERCUTINE PACKS THE HEADER DATA INTO A FORMAT FOR USE ON THE
FCP-11 PLCTTER.

```

```

CC 10 I=1,2
CC 10 J=1,81
10 PBUF(I,J)=0
10 IHBUF(I)=81
10 IHBUF(2)=10
CALL BUFFEROU(KTAPE,1,IHBUF,162,IND)
20 IF(IND.EQ.1) GO TO 20
30 RETURN
END

```



|       |     |        |        |
|-------|-----|--------|--------|
| FCCAL | FZE | 0      | TFDT   |
| \$    | SKN | \$+2   | \$-2   |
|       | ERU | BAKREC | FCRREC |
| RCEND | STZ |        |        |
|       | ERR |        |        |



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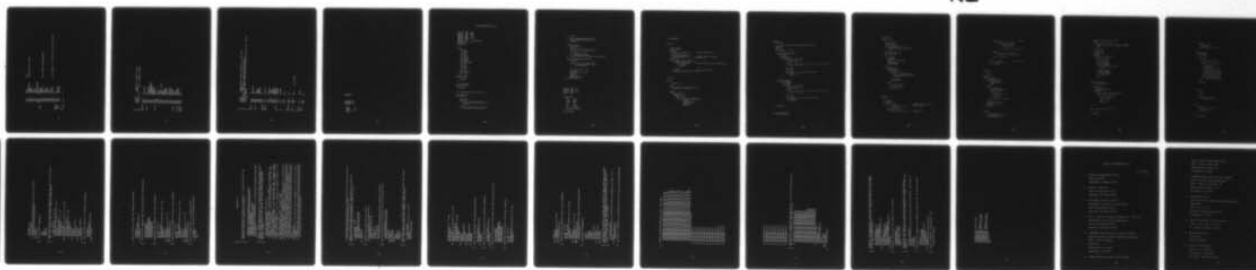
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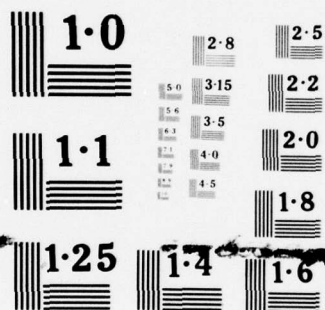
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MICROCOPY RESOLUTION TEST CHART



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# PLOT ROUTINE "aa.c"

```

#define XINT 320
#define YINT 8000
#define DELY 3200
#define DELX 16
#define AMPY 8000
#define NLINE 1
#define PI 3.141596525
#define NPT 150
int zero 0;
int one 1;

struct {
    int not;
    int line;
    int ldx;
    int ldv;
    int cptr;
    int nspt;
    int spot1;
    int spot2;
    int spot3;
    int hr,min,sec;
    int nft;
    int laq;
    int sr;
    int ld[3];
    int lp;
    int scl;
    int mo,day,yr;
} head, *h;

int hbuf[300];
struct data {
    int x;
    int yd;
};

struct data *d;
int dbuf[4000];
int np;
int nip 8;

int idev,pdev,sclx,scl,y,biask,tdev;

main(argc,argv)
int **argv;
{
    int i,j,n;
    char *cs;
    if((tdev = open("/dev/spp",1)) < 0){
        printf("cannot open spp #");
        exit();
    }
    if((pdev = open("/dev/rvp",1))<0){
        printf("cannot open rvp #");
    }
}

```

```

        exit();
    }
    if((idev = open("/dev/rmt6",0))<0){
        printf("cannot open rmt6 #");
        exit();
    }

    if(argc > 1){
        cs = argv[1];
        n = 0;
        while ( *cs >= '0' && *cs <= '9')
            n = n * 10 + *cs++ - '0';
        n = * 11;
        for ( i=0; i<n; i++)
            inp(idev, dbuf, 800);
        printf ("number of records skipped, %d#", n);
    }
    while((inp(idev, hbuf, 800))>0){
        h = hbuf;
        j = 0;
        for(i = 0; i< h -> line; i++){
            n = inp(idev, &dbuf[j], 800);
            j += 2*(h->not);
        }

        sclx = 030; scly = 03;
        biasx=50;
        np = h->not * h->line;
        scale();
        plot();
        cvers(pdev, 020);
        stty(pdev, &one);
    }
}

```

```

#define NBYT 254
#define NBLK 0
#define NSL 1250
#define DRAW 1

```

```

struct ipt{
    int    y;
    char   *xpb;
    char   yinc;
    char   xdir;
    int    yf;
    int    cx0;
    int    *flink;
    int    *blink;
} itab[7*NBYT], *ip, *ia;

char nb[NBYT];

```

```
int *dp[2000];
```

```
plot()
{
    struct tpt *s;
    int i,j,ie;
    sort();
    for(i = 0; i < NBYT; i++) //clear plot buffer
        pb[i] = 0;
    for(i = 0; i < NBLK; i++)
        write(pdev,pb,NBYT); //move to top of plot area
    ip = 0; ia = itab; //plot scan line
    j = 0;
    for(i = NSL; i > -1; i--){
        while(j < np && *dp[j] == i){
            ie = sip(dp[j]); //set up plot point for interpolation
            if(ie == 1)
                return;
            j++;
        }
        nib(i); //set up plot buffer
        write(pdev,pb,NBYT); //plot line
    }
}
```

```
int jsort;
```

```
sort()
{
    register i,k,t;

    i=0;
    for(d = dbuf; d < &dbuf[np*2]; d++){
        dp[i++] = &(d -> vd);
    }

    k=np;
    while ( k >> 1 ){
        jsort++;
        while ( jsort ){
            jsort = 0;
            for ( i=0; i< (np-k); i++)
                if ( *dp[i] < *dp[i+k] ){
                    t=dp[i];
                    dp[i]=dp[i+k];
                    dp[i+k]=t;
                    jsort++;
                }
        }
        k=k/2;
    }
}
```

```

sip(dpi)
int *dpi;
{
    int xi,yi,xl,yl,xr,yr,incy,fy,dirx,cx,*s,lcx,inc;
    int i,ie;
    s=dpi;
    lcx = 1;
    yi = *dpi--; xi = *dpi;

    if(++s < 8*(dbuf(2*nd))){
        xr = *s++;
        yr = *s;
        if(yr & DRAW){
            if((inc = yi - yr) >= 0){
                if((incy = inc) == 0)
                    dirx = nip;
            }
            else{
                for(i = 0; ((incy = (inc/(nip >> i))) == 0); i++);
                dirx = (1 << i);
            }
            fy = yr;
            cx = 0200;
            lcx = 0;
            ie = stack(yi-incy,incy,fy,xi,dirx,cx);
            if(i == 1)
                return(1);
        }
    }
    if(--dpi >= dbuf){
        if(yl & DRAW){
            yl = *dpi--;
            xl = *dpi;
            if((inc = yi - yl) >= 0){
                if((incy = inc) == 0)
                    dirx = -nip;
            }
            else{
                for(i = 0; ((incy = (inc/(nip >> i))) == 0); i++);
                dirx = -(1 << i);
            }
            fy = yl;
            cx = lcx;
            ie = stack(yi-incy,incy,fy,xi-1,dirx,cx);
            if(ie == 1)
                return(1);
        }
    }
    return(0);
}

```

```

stack(a,b,c,dd,e,f)
int a,b,c,dd,e,f;

```

```

{
    int *s;
    int i;
    struct iot *z;

    ia -> y = a;
    ia -> yinc = b;
    ia -> yf = c;
    if(dd >= NBYT && dd < 0){
        printf("bad scale x=%d#",dd);
        exit();
    }
    ia -> xpb = dd + pb;
    ia -> xdir = e;
    ia -> cxb = f;

    if(ip == 0){
        ip=itab;
        ip->flink=ip->blink=0;
        ia++;
        ia->blink=ip;
        ia->flink=0;
    }
    else{
        s=ia->blink;
        s->flink=ia;
        if(ia->flink == 0){
            s = ia;
            if(++ia >= &itab(7*NBYT)){
                printf("itab overflow #");
                return(1);
            }
            ia->blink=s;
            ia->flink=0;
        }
        else{
            s = ia -> flink;
            s -> blink = ia;
            ia -> flink = 0;
            ia = s;
        }
    }
}

nib(s1)
    int s1;
{
    int i,j,n;
    int *s; s = ip;
    while(s){
        if(s -> yf < 0) //setup plotting buffer
            if((s=free(s)) == 0) //delete point
                return;
        *s -> xpb = s -> cxb;
        if(s1 == s -> y){ //line break
            i = ((n = s -> xdir) > 0 ? n : -n);

```



```

        if( n < 0 )                //left
            for(j = 0; j < i; j++){
                if(s -> cxd == 0){
                    *s -> xpb = + 1;
                    s -> cxd = 1;
                }
                *s -> xpb = ! (s -> cxd == << 1);
            }
        else
            for(j = 0; j < i; j++){
                *s -> xpb = ! (s -> cxd == >> 1);
            }
        s -> y = - s -> yinc;

    }
    if(s) <= s -> yf)                //end of point
        s -> yf = -1;
    s = s -> flink;
}

```

```

free(s)
{
    int *s;
    {
        int *t;
        int i;
        struct ipnt *z;
        *s -> xpb = 0;
        if(s -> blink == 0){
            ip = s -> flink;
            ip -> blink = 0;
            t = ip;
        }
        else{
            t = s -> blink;
            t -> flink = s -> flink;
            t = s -> flink;
            if(t == 0){
                s -> flink = ia;
                ia = s;
                return(t);
            }
            t -> blink = s -> blink;
        }
        s -> flink = ia;
        s -> blink = ia -> blink;
        ia = s;
        return(t);
    }
}

```

```

scale()
{
    struct data *s;
    int dm,i,j,c,minx,miny;
    int dx[20],dy[20];
}

```

```

s = dbuf; minx = miny = 077777;
d=s;
for(i = 0; i < np; i++){
    minx = ((c = s -> x) < minx? c : minx);
    miny = ((c = s -> yd) < miny? c : miny);
    s++;
}
if(minx > 0)
    minx = 0;
if(miny > 0)
    miny = 0;
s=dbuf;
for(i = 0; i < np; i++){
    dm = s -> yd & 1;
    s -> x -= minx;
    s -> yd -= miny;
    s -> x /= sclx;
    s -> x += biasx;
    if(s->x >= NBYT){
        printf("overflow pb #");
        exit();
    }
    s -> yd /= scly;
    if(s->yd > NSL)
        s->yd = NSL-1;
    s -> yd =% 0177776;
    s -> yd =! dm;
    s++;
}
}

inp(idf,buf,nbyte)
int idf,*buf,nbyte;
{
    int t,t,n,c;
    struct{
        char c1,c2,c3,c4;
    } cf[1200], *s;
    s = cf;
    if((n = read(idf,cf,nbyte)) > 0){
        for(i = 0; i < nbyte/4; i++){
            c = s -> c2 << 2;
            t = c << 10;
            t =! s -> c3 << 6;
            t =! s -> c4;
            s++;
            buf[i] = t;
        }
    }
}

char *cbp,*loc,t1[132],ch[10];

conv(val)
int val;

```

```

{
    int a;
    if(a = val/10)
        conv(a);
    *cbp++ = val % 10 + '0';
}

```

```

conc(c1,c2,n)
char *c2;
int n,*c1;
{
    int i,m;
    for(i = 0; i < n; i++){
        if(i == 0)
            m = (*c1 & 07700) >> 6;
        else
            m = *c1 & 0077;
        if(m == 012)
            *c2 = '0';
        if(m >= 01 && m <= 011)
            *c2 = '1' + m - 1;
        if(m >= 021 && m <= 031)
            *c2 = 'A' + m - 021;
        if(m >= 041 && m <= 051)
            *c2 = 'J' + m - 041;
        if(m >= 062 && m <= 071)
            *c2 = 'S' + m - 062;
        c2++;
    }
    return(i);
}

```

```

skip(cnt)

{
    int cnt;
    int i;
    for(i = 0; i < cnt; i++)
        write(pdev,pb,2);
}

```

```

clr()
{
    int i;
    for(i = 0; i < 132; i++)
        t1[i] = ' ';
    t1[131] = '#';
}

```

```

mov(to,from,n)

```

```
char *to,*from;  
int n;  
{  
  int i;  
  for(i = 0; i < n; i++)  
    *to++ = *from++;  
}
```

```

C C C C C C C C C C
      "MIN/MAX 1"

PROGRAM TO PERFORM A SERIES OF STATISTICAL CALCULATIONS WITH THE
"ANALYSIS" DATA ON A SCAN BY SCAN BASIS.

      DIMENSION IFILE(320),IBUF(80),MASK(4),ISHT(4)
      DIMENSION JPT(320),MINPT(160),MAXPT(160)
      DATA (MASK(1),1=1,4),(ISHT(1),1=1,4)/37000000B,370000B,37000B,37B,1
      18,12,6,C/

PERMITS IDENTIFICATION OF THE NUMBER OF SCANS (NREC) TO BE INVESTI-
GATED, ATTENUATION APPLIED TO THE SET IN QUESTION (NATTN) AND NUMBER
OF FILES TO BE SKIPPED UNDER "FORSCAN" (NFILE).

      NAMELIST NREC,NATTN,NFILE
      DATA NFILE/0/,NREC/0/,ITAPE/1/
      2 FCFMAT(1/25X,'SCAN',10X,'PEAK',1CX,'VALLEY',1CX,'MAXMAX',10X,
      1,'MINMIN',/)
      2 FCFMAT(25X,14,10X,F5.2,10X,F5.2,11X,13,14X,13)

PERMITS INPUT OF NAMELIST VARIABLES, INCLUDING THE CALLING OF
"FORSCAN" TO SKIP OVER AN ARBITRARY NUMBER OF FILES.

      5 QUTPUT(102) 'DATA'
      INPUT(101)
      IF(NFILE.EQ.0) GO TO 100
      CALL FORSCAN(ITAPE,NFILE)
      NFILE = 0
      100 CC CONTINUE

      PRINTS COLUMN HEADINGS.

      WRITE(6,2)

PERMITS ANALYSIS OF PREVIOUSLY DELINEATED NUMBER OF SCANS ONLY.

      CC 40 N=1,NREC
      CALL BUFFERIN(1,1,IBUF,80,IND)
      7 IF(IND.EQ.1) GO TO 7
      IF(IND.EQ.3) GO TO 5

UNPACKS DATA FROM THE DATA TAPE.

      CC 25 K=0,1

```



```

M=K*160
CC 25 I=1,40
CC 23 J=1,4
22 IF(LE(M+J))=LRS(LAND(IBUF(K*40+I),MASK(J)),ISHT(J))
25 JPT(M+J)=(2*IFILE(M+J))+NATTN
25 M=M+4
25 CC CONTINUE

CC INITIALIZES PARAMETERS
CC
KZ=C
LZ=0
MXCNT=0
MNCNT=0

CC IDENTIFIES ALL OF THE SIGNAL WAVEFORM PEAKS AND VALLEYS AND PLACES
CC THEM INTO ARRAYS "MAXPT" AND "MINPT" RESPECTIVELY.
CC
CC 400 I=1,317
IF(JPT(I).EQ.0) GO TO 400
IF(JPT(I+1).LE.JPT(I)) GO TO 150
MXCNT=1
KJCNT=MXCNT+MNCNT
IF(KJCNT.NE.0) GO TO 400
MINTEM=JPT(I)
CC TO 200
150 IF(JPT(I+1).GE.JPT(I)) GO TO 400
MNCNT=-1
JJCNT=MXCNT+MNCNT
IF(JJCNT.NE.0) GO TO 400
MAXTEM=JPT(I)
CC TO 300
200 MNCNT=0
KZ=KZ+1
MINPT(KZ)=MINTEM
CC TO 400
300 MXCNT=0
LZ=LZ+1
MAXPT(LZ)=MAXTEM
400 CC CONTINUE

CC Sums the peak values for averaging purposes.
CC
MXFEAK=0
CC 500 I=1,LZ
MXPEAK=MXPEAK+MAXPT(I)
500 CC CONTINUE
C

```

```

C SUMS THE VALLEY VALUES FOR AVERAGING PURPOSES.
C
  MINVAL=C
  CC 600 I=1,KZ
  MINVAL=MINVAL+MINPT(I)
  6CC CCNTINUE

C COMPLETES THE AVERAGE PEAK VALUE AND AVERAGE VALLEY VALUE.
C
  XKZ=FLCAT(KZ)
  XLZ=FLCAT(LZ)
  XVAL=FLCAT(MINVAL)
  XPEAK=FLOAT(MXPEAK)
  FPEAK=XPEAK/XLZ
  VALLEY=XVAL/XKZ

C IDENTIFIES THE LARGEST PEAK VALUE (MAXMAX).
C
  CC 777 I=1,LZ
  MCN=0
  DC 700 J=1,LZ
  IF (MAXPT(I).LT.MAXPT(J)) GO TO 700
  MCN=NON+1
  IT=I
  7CC CCNTINUE
  IF (MCN.EQ.LZ) GO TO 799
  777 CCNTINUE
  755 MAXMAX=MAXPT(IT)

C IDENTIFIES THE SMALLEST VALLEY VALUE (MINMIN).
C
  CC 888 I=1,KZ
  MCN=0
  DC 800 J=1,KZ
  IF (MINPT(I).GT.MINPT(J)) GO TO 8CC
  MCN=MCN+1
  JT=I
  8CC CCNTINUE
  IF (MCN.EQ.KZ) GO TO 899
  888 CCNTINUE
  855 MINMIN=MINPT(JT)

C PRINTS OUTPUT DATA IN COLUMNAR FORMAT.
C
  WRITE(6,3) N,PEAK,VALLEY,MAXMAX,MINMIN
  4C CCNTINUE
  5C TO 5
  ENC

```

"MIN/MAX 2"

PROGRAM TO PERFORM A SERIES OF STATISTICAL CALCULATIONS WITH THE  
"ANCMALY" DATA ON A SELECTED BIN BASIS.

```

DIMENSION IFILE(320),IBUF(80),MASK(4),ISFT(4)
DIMENSION JPT(3600),MINPT(1800),MAXPT(1800)
DIMENSION XTIME(2500)
DIMENSION MM(20),KMM(20),XM(20)
DIMENSION NM(25),X(25),KM(25)
DATA (MASK(I),I=1,4),(ISFT(I),I=1,4),37000000B,3700000B,370000B,37000B,3700B,370B,1
18,12,6,0/

```

PERMITS IDENTIFICATION OF THE SET (NSET) AND BIN (NBIN) BEING INVEST-  
IGATED, SIGNAL LEVEL CHANGE TO BE DETECTED (NCB), ATTENUATION  
APPLIED TO NSET (NATTN) AND NUMBER OF FILES TO BE SKIPPED UNDER  
"FERRCN" (NFILE).

```

NAMELIST NSET,NBIN,NDB,NATTN,NFILE
DATA NFILE/0/,ITAPE/1/
2 FCFRMT(//5X,SET NUMBER ',I3,5X,BIN NUMBER ',I3,5X,PEAK = ',
1F5.2,' DB',5X,VALLEY = ',F5.2,' CB',5X,MAXMAX = ',I2,' DB',5X,
2,MINMIN = ',I2,' DB,/)
3 FCFRMT(37X,CHANGE NUMBER = ',I4,5X,ELAPSEC TIME = ',F6.2,' SEC')
13 FCFRMT(//32X,MEAN ELAPSED TIME = ',F7.3,' SEC,5X,STANDARD DEVIAT
1ICN = ',F6.3,' SEC')
4 FCFRMT(//37X,NUMBER OF ',I2,' DB CHANGES IN ADJACENT POINTS = ',I4
1//)
6 FCFRMT(62X,ELAPSED TIME = ',F6.2,' SEC')
16 FCFRMT(64X,TOTAL TIME = ',F6.2,' SEC')
17 FCFRMT(10X,FREQUENCY DISTRIBUTION OF ELAPSED TIMES IN VARIABLE WI
1CTF TIME BINS (ROW 1 = NUMBER, ROW 2 = PERCENT))
18 FCFRMT(//7X,N1,3X,N2,3X,N3,3X,N4,3X,N5,3X,N6,3X,N7,3
1X,N8,3X,N9,3X,N10,3X,N11,3X,N12,3X,N13,3X,N14,3X,N1
25,3X,N16,3X,N17,3X,N18,3X,N19,3X,N20,3X,N21,3X,N2
15 FCFRMT(5X,14,2X,13,2X,13,2X,13,2X,13,2X,13,2X,1
13,3X,13,3X,13,3X,13,3X,13,3X,13,3X,13,3X,1
22)
2C FCFRMT(//)
30 FCFRMT(//32X,TIME BINS N1 AND N2 EXPANDED TO 16 BINS .04 SECONDS
1WICE,/)
21 FCFRMT(//8X,N1-1,3X,N1-2,3X,N1-3,3X,N1-4,3X,N1-5,3X,N1-6
1,3X,N1-7,3X,N2-1,3X,N2-2,3X,N2-3,3X,N2-4,3X,N2-5,3X,
2N2-6,3X,N2-7,3X,N2-8,3X,N3-1,/)

```

```

32 FCRMAT(8X,I4,3X,I4,3X,I4,3X,I3,3X,I4,3X,I4,3X,I4,3X,I4,3X,I4
  1,2X,I4,3X,I4,3X,I4,3X,I4,3X,I4,3X,I4}
C PERMITS INPUT OF NAMELIST VARIABLES, INCLUDING THE CALLING OF
C "FCRSCN" TO SKIP OVER AN ARBITRARY NUMBER OF FILES.
C
5 CLTPLY(102) 'DATA'
  INPUT(101)
  IF(NFILE.EC.0) GO TO 100
  CALL FCRSCN(ITAPE,NFILE)
  NFILE = 0
100 CCNTINUE
   N=C
C
C UNPACKS DATA FROM THE DATA TAPE.
C
10 CALL BUFFERIN(1,1,IBUF,80,IND)
7  IF(INC.EC.1) GO TO 7
  IF(INC.EC.3) GO TO 45
  N=N+1
  CC 29 K=0,1
  M=M*160
  CC 25 I=1,40
  CC 23 J=1,4
  IFILE(M+J)=LRS(LAND(IBUF(K*40+1),MASK(J)),ISHT(J))
C PERMITS ANALYSIS OF PREVIOUSLY DELINEATED BIN(S) ONLY.
C
  IF((M+J).NE.NBIN) GO TO 23
  JPT(N)=(2*IFILE(M+J))+NATTN
  GO TO 40
23 CCNTINUE
  M=M+4
25 CCNTINUE
  CC 40 TC 10
  K2=C
  L2=C
  MXCNT=0
  MNCNT=0
  NRE=N-1
C IDENTIFIES ALL OF THE SIGNAL WAVEFORM PEAKS AND VALLEYS AND PLACES
C THEM INTO ARRAYS "MAXPT" AND "MINPT" RESPECTIVELY.
C
CC 400 I=1,NRE
  IF(JPT(I+1).LE.JPT(I)) GO TO 150
  MXCNT=1
  KLCNT=MXCNT+MNCNT

```



```

IF(KCUNT.NE.0) GO TC 400
MINTEM=JPT(I)
CC TC 200
15C IF(JPT(I+1).GE.JPT(I)) GO TC 400
MACNT=1
JCLNT=MXCNT+MNCNT
IF(JCLNT.NE.0) GO TC 400
MAXTEM=JPT(I)
CC TC 300
20C MACNT=0
KZ=KZ+1
MINPT(KZ)=MINTEM
CC TC 400
30C MACNT=0
LZ=LZ+1
MAXPT(LZ)=MAXTEM
40C CCNTINUE
MXPEAK=C
C
C SUMS THE PEAK VALUES FOR AVERAGING PURPOSES.
C
CC 500 I=1,LZ
MXPEAK=MXPEAK+MAXPT(I)
50C CCNTINUE
MINVAL=C
C
C SUMS THE VALLEY VALUES FOR AVERAGING PURPOSES.
C
CC 600 I=1,KZ
MINVAL=MINVAL+MINPT(I)
60C CCNTINUE
C
C COMPLETES THE AVERAGE PEAK VALUE AND AVERAGE VALLEY VALUE.
C
C
XKZ=FLCAT(KZ)
XLZ=FLCAT(LZ)
XVAL=FLCAT(MINVAL)
XPEAK=FLCAT(MXPEAK)
PEAK=XPEAK/XLZ
VALLEY=XVAL/XKZ
C
C IDENTIFIES THE LARGEST PEAK VALUE (MAXMAX).
C
CC 777 I=1,LZ
NCN=0
CC 700 J=1,LZ
IF(MAXPT(I).LT.MAXPT(J)) GO TO 700
NCN=NCN+1

```



```

      IT=I
700 CC CONTINUE
      IF (MCN.EQ.LZ) GO TO 799
777 CC CONTINUE
799 MAXMAX=MAXPT(IT)
C
C IDENTIFIES THE SMALLEST VALLEY VALUE (MINMIN).
C
      CC 888 I=1,KZ
      MCN=0
      CC 800 J=1,KZ
      IF (MINPT(I).GT.MINPT(J)) GO TO 800
      MCN=MCN+1
      JT=I
800 CC CONTINUE
      IF (MON.EQ.KZ) GO TO 899
888 CC CONTINUE
899 MINMIN=MINPT(JT)
      WRITE(6,2) NSET,NBIN,PEAK,VALLEY,MAXMAX,MINMIN
      KSAVE=JFT(1)
C
C INITIALIZES PARAMETERS.
C
      NUM=0
      NTL=0
      TTIME=0
      CTIME=0
      TAVE=0
      CC 500 I=1,21
      NM(I)=0
900 CC CONTINUE
      DC 501 I=1,16
      MN(I)=0
501 CC CONTINUE
C
C IDENTIFIES THE NUMBER OF TIMES THE DISCRETE SIGNAL SAMPLES IN A GIVEN
C BIN DEVIATE FROM A "SLIDING" REFERENCE VALUE (KSAVE) BY "NDB" DECI-
C BELS OR MORE; COMPUTES THE NUMBER OF SUCH CHANGES (NUM) AND THE
C LENGTH OF TIME BETWEEN THEM (TIME).
C
      CC 222 KL=1,NRE
      IF ((JPT(KL+1)-NDB).LT.KSAVE.AND.(JPT(KL+1)+NDB).GT.KSAVE) GO TO
1223
225 KSAVE=JPT(KL+1)
      TIME=(NTL+1)*.04
C
C CONSTRUCTS A FREQUENCY DISTRIBUTION FOR THE ELAPSED TIMES BETWEEN NDB

```

```

C      CHANGES UTILIZING VARIABLE WIDTH TIME BINS.
C
IF((TIME-GE.04).AND.(TIME-LT.32)) GO TC 61
IF((TIME-GE.32).AND.(TIME-LT.64)) GO TC 62
IF((TIME-GE.64).AND.(TIME-LT.1.0)) GO TC 63
IF((TIME-GE.1.0).AND.(TIME-LT.1.32)) GO TC 64
IF((TIME-GE.1.32).AND.(TIME-LT.1.64)) GO TC 65
IF((TIME-GE.1.64).AND.(TIME-LT.2.0)) GO TC 66
IF((TIME-GE.2.0).AND.(TIME-LT.2.32)) GO TC 67
IF((TIME-GE.2.32).AND.(TIME-LT.2.64)) GO TC 68
IF((TIME-GE.2.64).AND.(TIME-LT.3.0)) GO TC 69
IF((TIME-GE.3.0).AND.(TIME-LT.3.32)) GO TC 71
IF((TIME-GE.3.32).AND.(TIME-LT.3.64)) GO TC 72
IF((TIME-GE.3.64).AND.(TIME-LT.4.0)) GO TC 73
IF((TIME-GE.4.0).AND.(TIME-LT.4.32)) GO TC 74
IF((TIME-GE.4.32).AND.(TIME-LT.4.64)) GO TC 75
IF((TIME-GE.4.64).AND.(TIME-LT.5.0)) GO TC 76
IF((TIME-GE.5.0).AND.(TIME-LT.7.5)) GO TC 81
IF((TIME-GE.7.5).AND.(TIME-LT.10.0)) GO TC 82
IF((TIME-GE.10.0).AND.(TIME-LT.15.0)) GO TC 83
IF((TIME-GE.15.0).AND.(TIME-LT.20.0)) GO TC 84
IF((TIME-GE.20.0).AND.(TIME-LT.30.0)) GO TC 85
IF((TIME-GE.30.0).GC TC 86
GC TO 78
61 NM(1)=NM(1)+1
62 NM(2)=NM(2)+1
63 NM(3)=NM(3)+1
64 NM(4)=NM(4)+1
65 NM(5)=NM(5)+1
66 NM(6)=NM(6)+1
67 NM(7)=NM(7)+1
68 NM(8)=NM(8)+1
69 NM(9)=NM(9)+1
71 NM(10)=NM(10)+1
72 NM(11)=NM(11)+1
73 NM(12)=NM(12)+1
GC TO 78

```

```

74 NM(13)=NM(13)+1
   GC TO 7E
75 NM(14)=NM(14)+1
   GC TO 7E
76 NM(15)=NM(15)+1
   GC TO 7E
81 NM(16)=NM(16)+1
   GC TO 7E
82 NM(17)=NM(17)+1
   GC TO 7E
83 NM(18)=NM(18)+1
   GC TO 7E
84 NM(19)=NM(19)+1
   GC TO 7E
85 NM(20)=NM(20)+1
   GC TO 7E
86 NM(21)=NM(21)+1
   GC TO 7E

```

C  
C  
C

CONSTRUCTS A FREQUENCY DISTRIBUTION FOR 16 (.04 SEC WIDE) BINS CCM-  
PRISING TIME BINS N1,N2 AND PART CF N3.

```

77 IF (TIME.EQ..04) MM(1)=MM(1)+1
   IF (TIME.EQ..08) MM(2)=MM(2)+1
   IF (TIME.EQ..12) MM(3)=MM(3)+1
   IF (TIME.EQ..16) MM(4)=MM(4)+1
   IF (TIME.EQ..20) MM(5)=MM(5)+1
   IF (TIME.EQ..24) MM(6)=MM(6)+1
   IF (TIME.EQ..28) MM(7)=MM(7)+1
   IF (TIME.EQ..32) MM(8)=MM(8)+1
   IF (TIME.EQ..36) MM(9)=MM(9)+1
   IF (TIME.EQ..40) MM(10)=MM(10)+1
   IF (TIME.EQ..44) MM(11)=MM(11)+1
   IF (TIME.EQ..48) MM(12)=MM(12)+1
   IF (TIME.EQ..52) MM(13)=MM(13)+1
   IF (TIME.EQ..56) MM(14)=MM(14)+1
   IF (TIME.EQ..60) MM(15)=MM(15)+1
   IF (TIME.EQ..64) MM(16)=MM(16)+1
   CTIME=CTIME+TIME
78 NUM=NUM+1
   XTIME(NUM)=TIME
   WRITE(6,3) NUM,TIME
   NTL=0
   GC TO 222
   NTL=NTL+1
   CCNTINUE
   XX=FLOAT(NUM)

```

78

222  
222

C

```

C      COMPLETES THE PERCENTAGE OF EACH TIME BIN'S DEVIATIONS TO THE TOTAL
C      NUMBER OF DEVIATIONS FOR THAT SIGNAL WAVEFORM (FREQ BIN) AND ROUNDS
C      UP OR DOWN AS APPROPRIATE.
      CC 510 I=1,21
      X(I)=(NM(I)/XX)*100
      KM(I)=FIX(X(I))
      L=X(I)-FLCAT(KM(I))
      IF(U.GE..5) KM(I)=KM(I)+1
91C      CC CONTINUE
      CC 520 I=1,16
      XM(I)=(MM(I)/XX)*100
      KP(I)=FIX(XM(I))
      LP=XP(I)-FLOAT(KMM(I))
      IF(U.GE..5) KMM(I)=KMM(I)+1
92C      CC CONTINUE
C      COMPLETES TOTAL DATA SET ELAPSED TIME (CCTIME).
      TTIME=NTL*.04
      CCTIME=CCTIME+TTIME
      WRITE(6,6) TTIME
      WRITE(6,16) CCTIME
      NX=C
C      IDENTIFIES THE NUMBER OF TIMES DISCRETE ADJACENT SIGNAL SAMPLES
C      DIFFER BY "NCE" DECIBELS OR MORE AND COMPUTES THE NUMBER OF SUCH DEVI-
C      ATIONS.
      CC 333 JL=1,NRE
      IF((JPT(JL+1)-NDB).LT.JPT(JL).AND.(JPT(JL+1)+NDB).GT.JPT(JL)) GC
      1TC 333
      NX=NX+1
222      CC CONTINUE
C      COMPLETES THE AVERAGE AND STANDARD DEVIATION FOR THE ELAPSED TIMES.
      TSAVE=0
      TAVE=CCTIME/NUM
      CC 444 J=1,NUM
      XJ=(XTIME(J)-TAVE)**2
      TSAVE=TSAVE+XJ
444      CC CONTINUE
      STDDEV=(TSAVE/(NUM-1))**.5
C      PRINTS FREQUENCY DISTRIBUTION DATA.
      WRITE(6,4) NDB,NX

```

```

WRITE(6,13) TAVE,STCDEV
WRITE(6,17)
WRITE(6,18)
WRITE(6,19) (NM(J),J=1,21)
WRITE(6,30) (KM(J),J=1,21)
WRITE(6,31)
WRITE(6,32) (MM(J),J=1,16)
WRITE(6,32) (KMM(J),J=1,16)
GC TO 5
END

```



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